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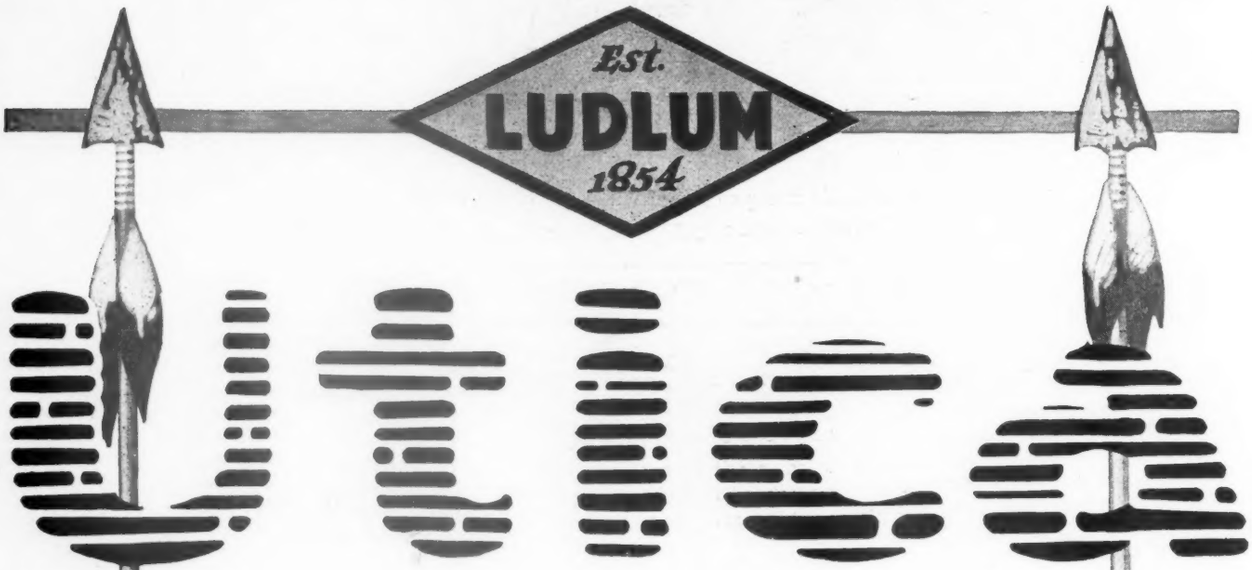

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Overhaul the Old Machines

Railroad shop and roundhouse men have become adepts in making the most of the machine tools and shop equipment available, usually finding some way to accomplish the results desired no matter how great the handicap. Old equipment is a serious drawback, however, especially if out of repair, and some men do not fully realize the present need and possibility of tuning up all shop machinery for greater production. Many old machines are too antiquated to be of value except for scrap but, on the other hand, the arrangement for more powerful drive, increasing speed or feed range, or strengthening some weak point may improve certain machines and make them real production tools. Advantage should be taken of the present opportunity to bring shop and enginehouse machinery and equipment up to the best possible state of repair. Repair gangs can be organized and taught the importance of careful, periodical inspection and repair. This will enable machines to be kept in operation with the fewest possible delays, and in certain cases the discovery of a weak or worn part will enable this part to be replaced, thus preventing a breakdown during some subsequent rush period. A great saving can be effected by developing and keeping in good repair time-saving jigs and fixtures which have demonstrated their value in actual service. Careful judgment should be used in the manufacture of these jigs because it is possible to go into refinements which are in no way warranted. The initial cost must always be balanced against the amount of work and possible savings. The recent government valuation showed a great abundance of small tools of all sizes, kinds and conditions of usefulness and it is apparent that real economy can be effected by a little attention to the determination of standards for these tools which are shown by experience to be satisfactory.

Roundhouse vs. Back Shop Repairs

It is important to maintain accurate figures regarding the cost of operating and maintaining cars and locomotives in order that equipment may be handled in such a way as to produce a maximum return for every dollar invested. The case cannot be put more plainly than was done recently by a prominent mechanical engineer in discussing running repair work which should be handled in roundhouses as against back shops. He said, "On some railroads it is a commonly accepted belief that minimum repair costs are attained by keeping equipment, particularly locomotives, in service as long as possible between shoppings. Other roads follow the practice of shopping locomotives oftener and doing little mechanical work on them in the roundhouse. It is not uncommon on a railroad, which follows to extremes the practice of keeping locomotives out of the shop as long as possible, to see work properly belonging under the head of heavy repairs done piecemeal in the roundhouse, care being taken to see that the cost of work done at each interval does not exceed the amount allotted for light or running repairs. There is obviously a limit beyond which such a policy cannot be pursued without making repairs cost more per dollar earned than would be necessary if locomotives were shopped at

reasonable intervals. The repairs could then be more conveniently and thoroughly made without unnecessary repetition of such operations as tearing down and reassembling parts. The limit at which roundhouse repairs cease to be profitable should be determined separately for different railroads. This limit will probably be different for different types or classes of power, and also for different parts of the same railway system. The mechanical department should determine such a limit for each type or class of power and be guided by it in formulating the policy of the road as regards locomotive repairs."

Wages, Cost of Living and Productive Efficiency

During the long controversy over wage rates, many arguments were presented regarding comparative wage scales and other factors on which wages are based under the Transportation Act. Fundamentally, however, the wages paid and the purchasing power of these wages depend on the production of all classes of workers. At the present time it is particularly important that this matter be thoroughly understood, and an editorial which appeared recently in the Railway Age dealing with some phases of this subject is therefore reprinted below.

In the recent wage hearings before the Railroad Labor Board some of the labor leaders protested against the policy of changing wages according to changes in the cost of living. The American Federation of Labor at its convention in Denver adopted a resolution denouncing the basing of wages wholly or mainly on the cost of living as "a violation of the whole philosophy of progress and civilization and a violation of sound economic theory and thoroughly without logic or scientific support."

Most of the advances in wages which have been made in this country since before the war have been based on increases in the cost of living. This has been especially true in the railroad business. Labor leaders were glad to accept advances in wages based on the cost of living when it was increasing. They repudiate the principle now that the cost of living is declining.

Having secured great advances in wages based on increases in the cost of living, the labor leaders cannot hope to prevent all reductions when it is declining. The cost of living is declining because prices are declining. Prices are declining because there is reduced demand for commodities at the high prices which have prevailed. Wages must be reduced when prices sharply decline, because employers cannot pay war wages when they can get only pre-war prices without being bankrupted. In many industries the wages being paid exceed the total earnings of those industries when lower prices and rates were in effect a few years ago. In the railroad industry, for example, the total wages paid in 1920 exceeded the total earnings of 1916. The restoration of pre-war prices means in many industries restoration of pre-war earnings. No industry can pay to labor all it earns.

However, while in a period when prices are falling so much wages must come down, just as in a period when prices are greatly advancing they must go up, the labor leaders are on a sound economic ground when they condemn the practice of basing wages wholly or mainly on the cost of living. A large majority of the people of the world work with their hands. If wages were always to vary directly with the cost of living, the working people never would get for their work an increased amount of comforts and luxuries. This would mean that working people would derive no benefits from the material progress of civilization. If a large majority of the people derived no benefit from it, this so-called "progress" would be misnamed.

Upon what, then, should wages be mainly based? They should be mainly based on productive efficiency. Capital furnishes the directing brains, the physical plant, the tools, of industry. Working people furnish the manual skill and labor. Both should constantly increase their efficiency. The increasing efficiency of both will result in a constantly increasing product in proportion to the capital invested and the number of workers. Equitable division of this increased product would and should result in increasing returns to both.

Increases of industrial efficiency and output will, however, be seriously hindered or prevented if either of the partners in industry, capital and labor, constantly tries to defeat all efforts of the other partner to secure increases of efficiency and output. This is virtually what is being done in many industries now. Capital is constantly trying to increase production in proportion to the amount invested and the men employed. The members of many labor unions, under reactionary leadership, are just as constantly trying to prevent increases of output. These reactionary leaders are sometimes called "radicals." They are, in fact, the most reactionary men in civilized countries. If they should accomplish all they attempt, the efficiency of modern industry would be destroyed and its output so reduced that every workingman's family would suffer curtailment of its comforts and luxuries. These labor leaders restrict the number of brick that men can lay; they insist upon classifications which increase the number of men employed to do a given job; they exhaust their ingenuity in devising ways to curtail not only the number of hours which men work, but the amount each does in each hour he does work. Every measure of this kind tends to reduce the number of houses built, the number of suits of clothes made, the quantity of food produced, the amount of transportation rendered.

No better examples of the results of these labor union tactics could be cited than are afforded by developments in recent years on the railroads of this country. Until 1917 there was a steady increase in the amount of transportation service rendered in proportion to the number of men employed. Since then, while wages have been greatly increased, the output per employee has sharply declined.

In 1913 the amount of public service rendered for each dollar of interest and dividends paid to owners of railway securities was 459 ton-miles and 47 passenger-miles. In 1917 it was 582 ton-miles and 53 passenger-miles. In 1920 it was 611 ton-miles and 64 passenger-miles. The increase between 1913 and 1920 in freight service rendered for each dollar of return paid to capital was 33 per cent and in passenger service 36 per cent. Contrast these statistics with the following regarding the production of transportation to the wages paid: In 1913 for each dollar of wages paid the railroads rendered 245 ton-miles of freight service and 25 miles of passenger service; in 1917, 247 ton-miles and 22 passenger-miles; in 1920, only 121 ton-miles and 13 passenger-miles of service. The decrease in transportation output for each dollar of wages paid between 1913 and 1920 was about 50 per cent.

The Railway Age pointed out months ago to labor leaders and their followers that the only way they could hope to retain all, or even a large part, of the advances in wages made since before the war was through increased efficiency. High wages and low efficiency for any considerable time always have been and always will be incompatible in any industry. The labor leaders having, however, obtained rules, hours and working conditions from the Railroad Administration which greatly reduced the efficiency and output of the average employee, sought to perpetuate instead of to eliminate, to aggravate instead of to mitigate, the rules and conditions which produced the demoralization. They sought at the same time to maintain a scale of wages which was incompatible with the gross inefficiency that prevailed. They tried to both eat their cake and have it. The result was to force up railroad rates and at the same time bring the railroads to the verge of bankruptcy. Largely in consequence

of these things, 500,000 railway men have speedily found themselves out of employment, and now $400,000,000 of the wage advances has been ordered rescinded.

The labor leaders are right—wages should not be based entirely or mainly on the cost of living. Furthermore, in the long run they cannot and will not be. Efficiency of production always has and always will, in the long run, bring advances in wages largely regardless of the cost of living. Inefficiency of production always has and always will, in the long run, bring reductions of wages largely regardless of the cost of living. The highest wages in proportion to the cost of living are, and always will be, paid in those countries where the efficiency of capital and labor are the greatest. The lowest wages in proportion to the cost of living are and always will be paid in those countries where the efficiency of capital and labor are the lowest. In the United States wages will increase more than the cost of living in the future as they have in the past if the productive efficiency of capital and labor increases, and decline more than the cost of living if efficiency declines.

Most of the present generation of labor leaders are engaged constantly in trying to reduce wages in proportion to the cost of living by trying to reduce productive efficiency. They may be unconscious of it, but this is what they are doing. Some time, perhaps, the workingmen will choose leaders who recognize not only the truth that wages should not be based on the cost of living, but the additional truth that in the long run they always have been and always must be based upon productive efficiency. The worst enemy the workingman has is the man who exhausts his ingenuity and energy in trying to reduce the amount of efficient work that workingmen do.

Centralized Production Shops Needed

While most railroads are not financially in a position at the present time to establish centralized production shops, railroad men are coming to realize more and more the need for this important department. Arrangements for handling duplicate machine operations in one central department enable highly productive, specialized machines to be segregated at this point and effect economies in manufacture that can be obtained in no other way. Elsewhere in this issue is an article entitled, "Manufacturing Standard Locomotive Repair Parts," which is devoted to a consideration of this subject, and gives methods of standardizing small repair parts and determining proper step sizes, together with approved practices in the manufacture of these duplicate parts.

The centralized production shops must be prepared to furnish parts in a finished or semi-finished state for distribution to the stores department and subsequently to shops and engine houses throughout the system. Two benefits result from this practice. Not only are the parts manufactured in bulk at a minimum cost, but when they can be secured at local shops and terminals in a finished or semi-finished condition, very little time is required to fit them to the locomotive or car in question. Equipment is, therefore, repaired and returned to service in a minimum length of time and this effects important economies since the first cost of locomotives and cars is so high that every hour they are unnecessarily held out of service reduces the revenue earned and allows interest and depreciation charges to accumulate.

It is pointed out in the article that motion work pins and bushings, axles, crank pins, valve motion levers, crossheads, piston rods and other parts too numerous to mention may be machined from the rough casting, forging or bar stock to a finished or semi-finished state. Machine operations on most of these parts can be performed to good advantage in centralized production shops, but operations involving single set-ups, such as some planing jobs and most lathe work can be done as cheaply in one place as another. The necessity of standardizing thread sizes is pointed out; this is important because parts manufactured in the central shop will find their way to different shops and engine houses, and in many cases will be of absolutely no use unless the thread sizes are interchangeable. It is understood that thread standardization cannot be obtained without suitable internal and external thread gages of the Go-and-Not-Go type, used in conjunction with master reference gages.

The importance of grinding operations in central shops is stressed throughout the article. Many advantages result from the use of grinding machines, experience having demonstrated that greater accuracy and a better finish are secured in a shorter time by grinding than by any other method. In addition the fact that the finished operation is to be performed by grinding enables heavier cuts to be taken by the automatics, with resultant increased production. As in the case of external grinders it is important to have rugged machines for internal grinding. A chucking equipment is preferred and the machine should have ample belt power and rigidity to remove metal quickly. By the use of production internal grinders the cost of grinding the bores of bushings will be more than offset by the advantages of accuracy and interchangeability.

A Need for Fundamental Data

The history of agricultural development in the United States presents a broad parallel to the development of railway transportation. Beginning with vast undeveloped resources, of fertile soil in the one case and of revenue resources in the other, the early development in each case was extensive and not intensive; there was little need for attention to efficiency in the utilization and exploitation of these resources. Any seed placed in average soil will grow. But there is a vast difference between the growing of crops on this simple basis and the scientific farming now becoming so general, by which the forces of nature are controlled through accurate, scientific knowledge of soils and fertilizers, of seed quality and of plant and insect life, in order that the soil resources may be made to produce the maximum of return and at the same time be retained unimpaired for the future. Given a locomotive—any locomotive—, a car—any car—, and a track—any track provided it is strong enough to hold up the locomotive—, and traffic can be moved. But there is a vast difference between this simple railroad and the type of well-balanced transportation machine which is required to move traffic with the high degree of efficiency that present conditions demand if the net return is to be sufficient to insure it an unimpaired future existence.

Unfortunately, the degree of science which has been developed with the growth of the transportation industry will not compare favorably with that in the field of agriculture. Science is founded on facts and the fund of fundamental facts pertaining to the railroad business is still far from adequate. It is true that through the reports of the carriers to the Interstate Commerce Commission a large amount of invaluable data have been gathered but these are general in character and leave many specific problems untouched.

One of the most important of these problems so far as the mechanical department is concerned is the economics of freight car design, operation and maintenance. Freight cars are built by the thousands and, unfortunately, very little broad study is given to them. There are many phases of the freight car problem susceptible of scientific study by the railroads individually without awaiting the attention of a central agency such as the Interstate Commerce Commission or even the American Railway Association. For instance, how many railroads have ever attempted to determine the most economi-

cal rate of depreciation so that when capital turnover is balanced against the average annual cost of maintenance throughout the life of the equipment, the minimum charges to operating expenses may be obtained? How many railroads know just what proportion of the total cost of maintaining their freight cars is chargeable to any specific series of cars? The answer to these questions are not difficult to obtain. Indeed, it is probable that all of the basic data required are now available, awaiting only the proper classification and analysis.

It is true that such a classification and analysis would involve an outlay, but an outlay so small in proportion to the expenditures involved that it is inconceivable that a hundred-fold return would not be obtained by the ability to form sound judgments on a foundation of facts which such studies would make possible, instead of on the basis of more or less unsupported personal opinion and prejudice as is necessary at present. With thousands of weak and unsuitable freight cars persistently retained in service, in many cases against the better judgment of mechanical department officers, would it not pay them to introduce such studies at the present time?

The Foot-Pound Versus The Horsepower

When mention is made of "the characteristics of the steam locomotive" one immediately visualizes the drawbar pull-speed curve and the horsepower-speed curve, showing respectively the maximum drawbar pull and the maximum horsepower which the locomotive is capable of developing at all points within the full speed range of the locomotive. These characteristics undoubtedly are of value for the comparative study of locomotive designs, but when considering the service which a freight locomotive is to render, the less frequently discussed area which lies under these two curves becomes a matter of great interest.

As commonly operated, the freight locomotive is a producer of work rather than a producer of power. The problem is one of performing a definite amount of work within a fixed distance, in which the element of time ceases to be a factor at the point where overtime no longer has to be paid. Since the fuel cost is about equal to the cost of crew wages in freight train operation, fuel economy in the production of the unit of work becomes a matter of greater interest than the maximum horsepower capacity which the locomotive is capable of developing and the effect of speed on the fuel consumption per unit of work must be as carefully considered as its effect on punitive overtime.

By inference, the use of the horsepower as the unit of capacity for freight locomotives leads to the assumption that this capacity may be utilized to equal advantage irrespective of the speed at which it is attained. From the standpoint of maximum horsepower capacity the highest fuel economy is not attained at speeds much below 30 or 35 miles an hour, when the maximum horsepower is developed. From the standpoint of work, measured in foot-pounds, it is recognized in every-day practice that a given tractive effort may be maintained most economically at speeds considerably below the highest at which that tractive effort can be maintained.

Data from locomotive tests confirm practical experience in this respect and show that the maximum horsepower capacity at a given tractive effort can be obtained only at the expense of a sharp increase in fuel consumption per million foot-pounds of work within a comparatively small range of speeds. A Mikado type locomotive capable of developing about 65 per cent of its starting tractive effort at 25 miles an hour does so with an increase in fuel consumption of about 55 per cent over the amount required to maintain the same tractive effort at 15 miles an hour and with a 36 per cent increase over the amount required at 20 miles an hour. For this same locomotive there is also a tendency, although much less pronounced, toward an increase in the fuel consumption per unit of work when speed increases are obtained by reducing the tonnage and the cut-off is maintained constant.

These facts are indicative of some of the characteristics of the steam locomotive when operating under conditions which lie in the comparatively uncharted area under the commonly used characteristic curves. Since they are of great practical importance in the actual application of the freight locomotive to the production of ton-miles, it is suggested that in analyzing test results and locomotive operation in general, the locomotive be regarded more in the light of a work producer than of a power producer. This will lead to a more accurate estimation of ton-mile fuel costs as a factor in determining the best methods of utilizing freight locomotive capacity, without detracting in any way from the attention to be given to speed so far as it affects the wage costs.

Maintenance Cost of Combustion Chambers

Some American railroads have for many years constructed locomotive boilers with combustion chambers. During the last five years their use has become quite general on nearly all roads burning high volatile coal and in most cases the results have been satisfactory. However, combustion chambers, like all other locomotive appliances, have certain disadvantages. Some roads have experienced considerable trouble with cracking of the plates in the combustion chamber and some mechanical officers have proposed to eliminate the combustion chambers to overcome this difficulty.

As the economy of combustion chambers is now being questioned, it may be pertinent to review the results of investigations to determine the benefits derived from this type of construction. In a locomotive burning an average grade of bituminous coal under ordinary conditions of firing over 50 per cent of the heat generated in the firebox is due to the burning of the gases in the fuel. To obtain full heating value from the volatile matter in the coal, the gases of combustion must be given time to mix with oxygen at a high temperature. This can only be done by lengthening the flame passage by baffles in the firebox, or by increasing the volume through the use of combustion chambers. With bituminous coal and high rates of combustion, both methods must be utilized if reasonably good boiler efficiency is to be obtained.

Tests of similar locomotive boilers with and without combustion chambers showed that the boiler without the combustion chamber reached its maximum capacity at a rate of combustion of 135 lb. of coal per square foot of grate per hour, while the capacity of the boiler with the combustion chamber continued to increase even at a rate of 160 lb. At a rate of combustion of 135 lb. the furnace efficiency of the boiler without the combustion chamber was only 62 per cent, while with the combustion chamber it was 74 per cent.

The saving in fuel effected by the combustion chamber is so large that it would probably far outweigh the increased cost of repairs in any boiler of reasonably good design. Frequent cracking of the combustion chamber sheets is probably due to too rigid construction which under ordinary conditions can be overcome quite readily by the use of flexible staybolts. Another important cause of failure may be the poor material that has been accepted under the specifications prepared during the war. However serious the trouble may be, an attempt should be made to determine the cause and correct it in order to avoid sacrificing the improved boiler efficiency which is obtained by the use of combustion chambers.

The Illinois Central made a record for passenger train performance during the month of May, when a total of 13,567 trains were operated, 13,461, or 92.2 per cent., of which maintained scheduled time.

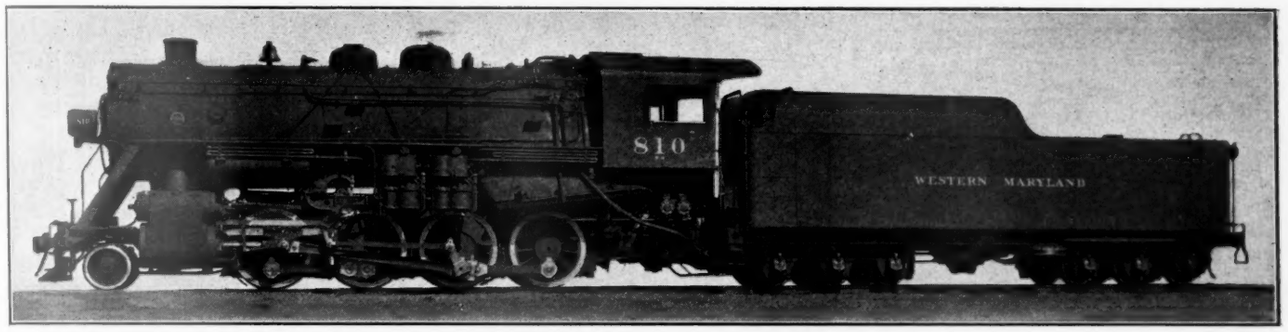


Photo by International

Consolidation Locomotives for the Western Maryland

Weight and Tractive Effort Establish New Records for This Type—Tender of 15,000 Gallons Capacity Used

THE design of locomotives adapted to special operating conditions has led to the development of some notable examples of the standard types of freight and passenger power. A striking illustration of the high tractive effort that can be secured with a restricted wheel base is found in the Consolidation locomotives recently built for the Western Maryland by the Baldwin Locomotive Works. These engines have a rated tractive effort of 68,200 lb., the weight on drivers being 268,200 lb. or 67,050 lb. per pair of drivers. In these particulars they exceed any engines of either the Consolidation or Mikado types heretofore constructed by the builder.

During the past ten years the Consolidation has been largely displaced by the Mikado and in view of the selection of the former type by the Western Maryland, a brief discussion of the advantages and disadvantages of each may be of interest.

The Consolidation type locomotive was introduced in this country in 1866, the first engine of this type having cylinders of 20 in. diameter and 24 in. stroke, and a total weight of 90,000 lb. The Consolidation wheel arrangement is well adapted for general freight service and following its introduction was widely adopted, being for many years the prevailing type of freight power. About twelve years ago the Mikado began to displace the Consolidation and comparatively few of the latter type have been built for heavy freight service in recent years. The principal advantage of the Mikado lies in the fact that the longer wheel base, with a trailing truck, permits the use of a longer boiler barrel and a deeper firebox, thus improving the capacity and efficiency of the boiler. The Consolidation, however, can be designed to give equally high tractive effort at low speeds where the boiler capacity is not the limiting factor. The absence of the trailing truck eliminates certain maintenance costs and the non-symmetrical wheel base is easier on the track.

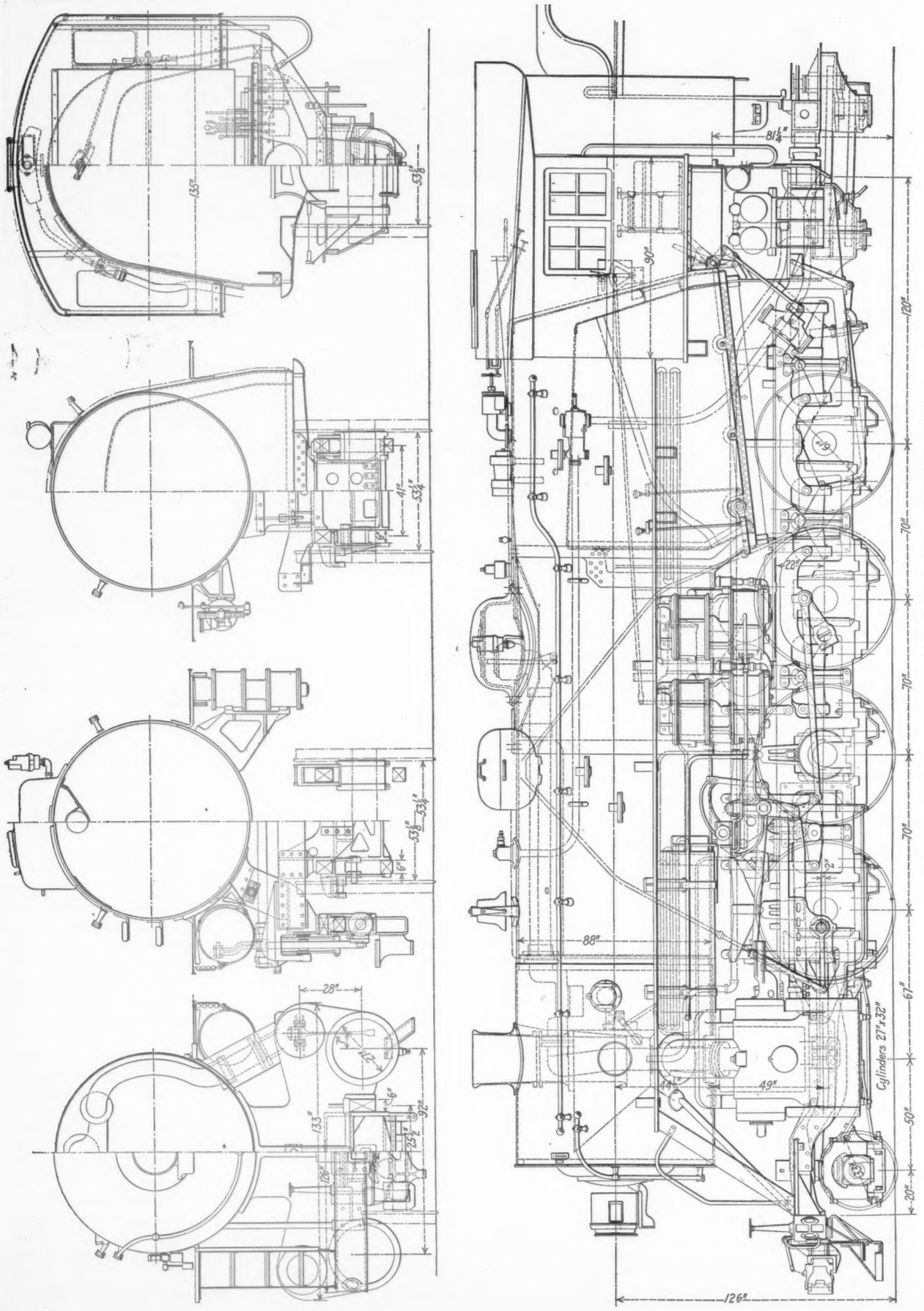
The improved utilization of fuel and higher speed capacity have generally been considered to outweigh the disadvantages of the Mikado. However, Consolidations are still used to a considerable extent for heavy drag service where slow speeds will suffice. With driving wheels of the size that are suitable for work of this kind, it is possible in a Consolidation engine to obtain a reasonably good boiler design. The firebox throat can be made of sufficient depth to install a brick arch without raising the boiler to an excessive height. Such a locomotive, with a high percentage of total weight on driving wheels, is well fitted for heavy, slow speed service.

The Consolidation engines which the Baldwin Locomotive Works are now building for the Western Maryland are a remarkable example of locomotives for such work. These engines are designed to operate on 90 lb. rails, to traverse curves of 22 deg. and grades of 3½ per cent. The total weight is 294,900 lb., while the weight on drivers (268,200 lb. total or 67,050 lb. per pair of drivers) and tractive effort (68,200 lb.) exceeds that reached in any Mikado or Consolidation type locomotives heretofore. The ratio of adhesion is 3.93, indicating that the weight on drivers is utilized for tractive purposes to the fullest possible extent. As compared with a design of heavy Consolidation built for the Western Maryland in 1910 and using saturated steam, these new locomotives show an increase in total weight of 31 per cent, and in tractive effort of 40 per cent.

The boiler is of the straight top type with horizontal roof sheet and sloping throat and back head. The diameter of the first course of the barrel is 88 in. The throat has a depth of 19 13/16 in., measured from the under side of the barrel to the bottom of the mud ring. The firebox is supported at the front and back on vertical plates. The front end of the crown is supported on three rows of expansion stays, and about 550 flexible staybolts are applied in the breaking zones in the sides, throat and back. The distance between the tube sheets is 15 ft. 3 in. Fifty superheater tubes of 5½ in. diameter and 240 water tubes of 2¼ in. diameter are used. The ratio of length to internal diameter in the water tubes is 91.5, this low value indicating that the capacity of the boiler has been made high at some sacrifice of fuel economy. The safety valves are placed just forward of the firebox and as the clearance is limited, they are tapped directly into the boiler shell instead of being mounted on an auxiliary dome.

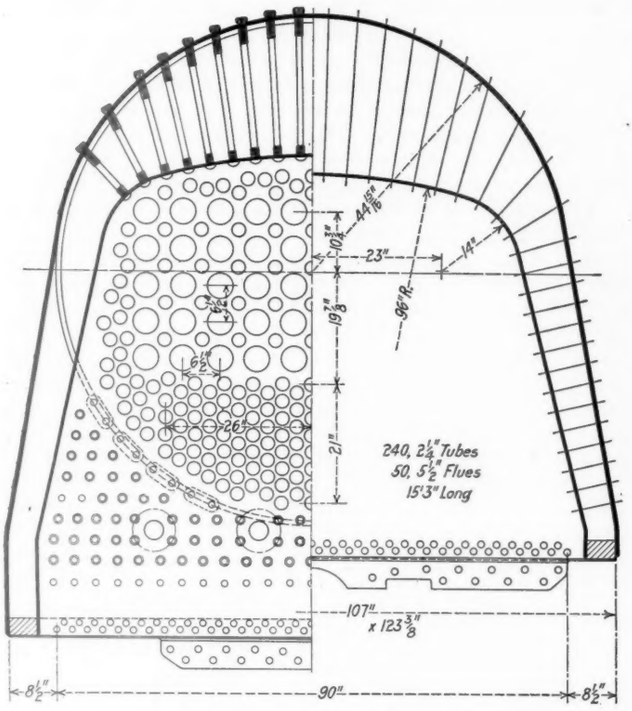
The firebox equipment includes a brick arch, power operated fire-door and grate shakers and a Standard stoker. The drop plates are at the back of the grate. The ash pan has two hoppers with swing bottoms, both of which are controlled by one handle. Flushing pipes are applied for washing ashes from the slopes of the pan.

The frames are 6 in. wide, spaced 41 in. between centers, each frame being cast in one piece with a single front rail to which the cylinders are bolted. The transverse bracing calls for special attention. A most substantial steel casting, placed just back of the cylinders, extends the full length of the leading driving pedestals and serves as a fulcrum for the driving brake shaft. The guide yoke crosstie is also of cast steel and it is extended back sufficiently far to brace the sec-



Side Elevation and Cross Sections of the Western Maryland Consolidation

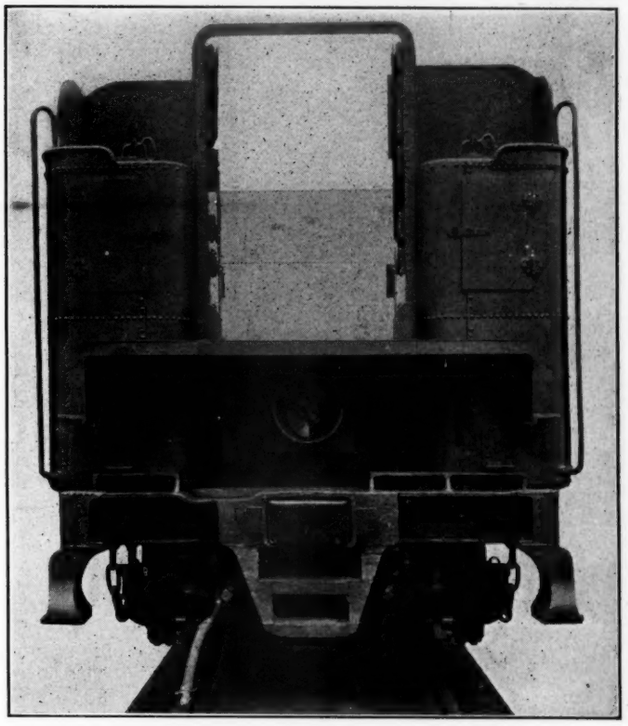
ond driving pedestals. This crosstie also serves as a support for the driving brake cylinders, one of which, because of lack of room, is placed in a horizontal, and the other in a vertical position. The two brake shaft arms are placed at right angles to each other, the horizontal cylinder being connected to



Cross Sections Through the Firebox

the vertical arm by means of pull rods, while the vertical cylinder is directly connected to the horizontal arm. The frame braces further include a steel casting at the main driving pedestals and a casting, placed between the main and rear pedestals, which is bolted to both the top and bottom frame rails and serves as a support for the forward end of the firebox.

The cylinders are fitted with gun iron bushings, and the steam distribution is controlled by 14 in. piston valves. Walschaert valve motion is used and the gears are controlled by the Pittsburgh power reverse mechanism. The equipment includes automatically operated drifting valves designed by the railway company. The links are carried on longitudinal supports of cast steel, which are bolted in front of the guide bearers, and at the rear to a crosstie placed between the second and third pairs of drivers. The reverse shaft is located immediately in front of the links and the lifting arms extend in a backward direction, each radius rod being suspended at its rear end. The valve motion is so designed that the link blocks are down when running ahead. Other machinery details include cast steel piston heads of dished section with cast iron bull rings and packing rings. The guides and crossheads are of the Laird type. The main rod stubs are

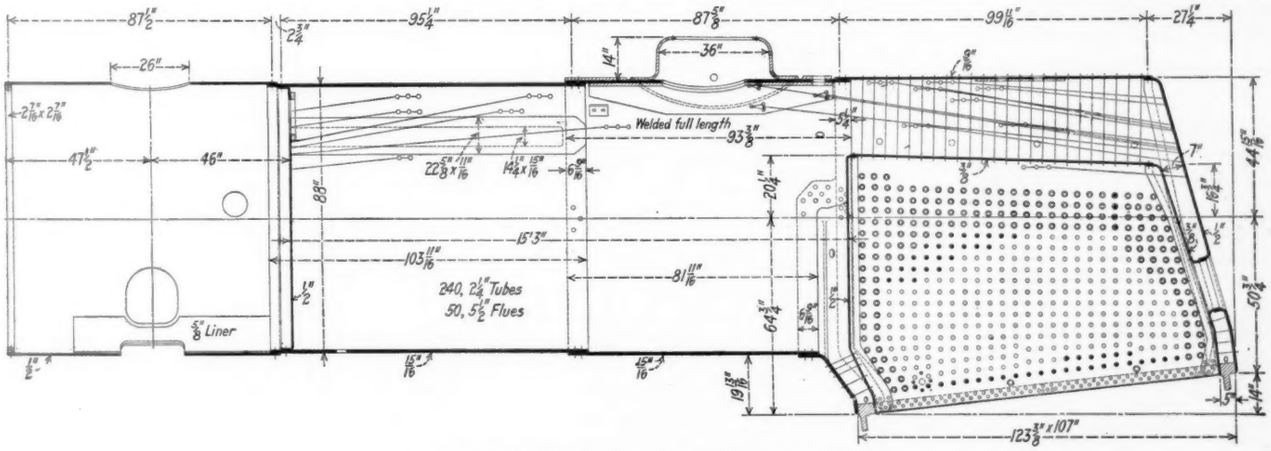


Front View of the High-Capacity Tender

of the open end type which permits renewing the brasses without removing the eccentric cranks.

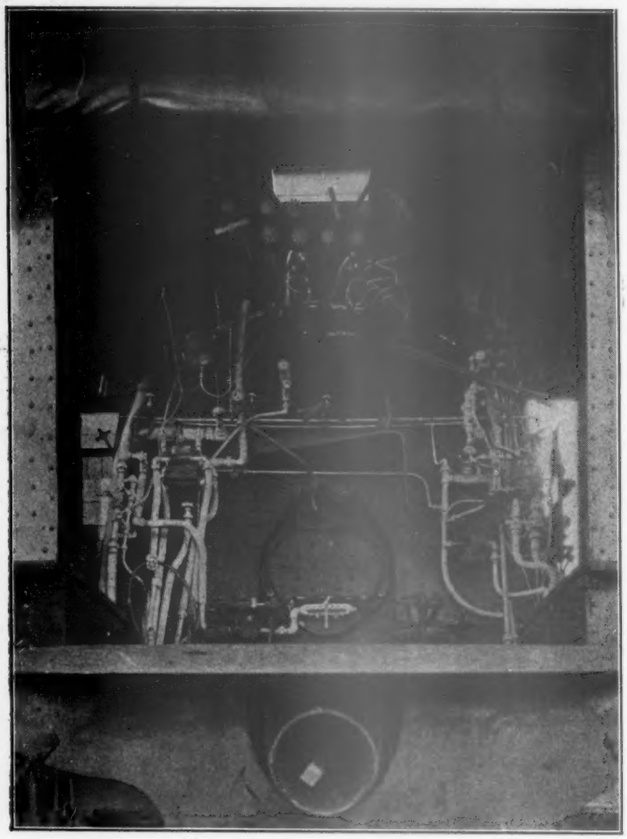
The driving boxes are of cast steel and are fitted with bronze hub faces and brass lined pedestal faces. Cast iron shoes and wedges are used, the latter being of the self-adjusting type. The driving axles and engine truck axle are of heat treated steel, and flanged tires are used on all the wheels. Both front and back drivers have flange oilers.

The truck is of the Economy constant resistance type and



Boiler of the Western Maryland Consolidation

is equalized with the first and second pairs of driving wheels. Dolphin beams are placed over the boxes on the third and fourth pairs of drivers and are connected on each side of the locomotive with three inverted leaf springs which are placed below the upper frame rail. Limited clearance space



Breather Pipes for Use in Tunnels Are a Novel Feature of the Cab Equipment

under the firebox did not permit placing the springs over the boxes of the two rear pairs of wheels.

The cab is unusually roomy and comfortable with all fittings placed within convenient reach of the crew. The injectors and steam turret are placed outside the cab and have extension handles identified by small aluminum plates with raised letters. The equipment includes a breather pipe for providing fresh air while passing through tunnels. This arrangement consists of a ½ in. pipe placed across the boiler back head and having five ¼ in. globe valves equally spaced, each fitted with 3 ft. of ½ in. hose. The air supply is drawn from the brake system.

An interesting detail is the arrangement of the hand rail columns, which are in the form of clamps, so that the hand rail can be readily taken down without removing the columns. The headlight dynamo is placed on the right hand side of the boiler, ahead of the cab, and the wiring is run through the hand rail. The pilots are adjustable as to height above the rail and are of short design so that two locomotives can be coupled pilot to pilot without interference.

The tenders of these locomotives are of special interest, having the unusual capacity of 15,000 gal. of water and 16 tons of coal. The tanks are comparatively long and low in order to keep the center of gravity as low as possible. The extreme length of the tank is 36 ft. 6 in. and the width 10 ft. 5½ in., while the depth is 6 ft. 6 in. with a collar 32 in. high on each side of the fuel space. The sides and rear of the fuel space are sloped so that the coal will gravitate into the stoker trough even when only a small amount is on the tender. The stoker trough is constructed so that it may be removed as a complete unit even when the tender has a full load of coal. An unusually complete arrangement of transverse and longitudinal dash plates is applied to prevent the water from surging.

The frames are of one piece cast steel construction made by the Commonwealth Steel Company. The total length is 38 ft. 8 in. and the width over outside sills is 8 ft. 11¼ in. The distance between truck centers is 22 ft. 11¾ in.

The trucks are of the six wheel type, manufactured by the Commonwealth Steel Company. The truck frames are constructed with longitudinal and transverse members of steel, cast in one piece. The pedestals are bolted to the frames and the wheel loads are equalized on each side. Swing bolsters are used and are hung on three-point suspension links. The brakes are of the clasp type. It is found in practice that these tenders take curves smoothly and are very easy riding.

The locomotives have a height of 15 ft. 10 in., a width over cab boards of 11 ft. 4 in., and a total length of engine and tender, measured from face to face of beams, of 80 ft. 4¾ in. Their leading dimensions, in comparison with those of a number of heavy Consolidation type locomotives built during the past few years by the Baldwin Locomotive Works, are given in the accompanying table.

COMPARISON OF RECENT TYPES OF CONSOLIDATIONS

	Pennsylvania Lines	Union Railroad	Bessemer & Lake Erie	Lake Superior & Ishpeming	Philadelphia & Reading	Western Maryland
Cylinders	26 in. by 28 in.	25 in. by 32 in.	26 in. by 30 in.	26 in. by 30 in.	25 in. by 32 in.	27 in. by 32 in.
Valves	Piston 14 in. dia.	Piston 12 in. dia.	Piston 14 in. dia.	Piston 14 in. dia.	Piston 13 in. dia.	Piston 14 in. dia.
Boiler type	Belpaire	Straight top	Straight top	Straight top	Wootten con.	Straight top
Diameter	78½ in.	84 in.	84 in.	88 in.	79¼ in.	88 in.
Working pressure	205 lb.	190 lb.	190 lb.	185 lb.	200 lb.	210 lb.
Firebox, length	110¼ in.	111½ in.	120⅛ in.	108⅞ in.	126¼ in.	112 in.
Firebox, width	72 in.	70¼ in.	70¼ in.	78¼ in.	108¼ in.	96¼ in.
Tubes, diameter	5⅜ in. and 2 in.	5½ in. and 2¼ in.	5½ in. and 2¼ in.	5⅜ in. and 2 in.	5⅜ in. and 2 in.	5½ in. and 2¼ in.
Tubes, number	5⅜ in.—36 2 in.—265	5½ in.—36 2¼ in.—200	5½ in.—36 2¼ in.—200	5⅜ in.—45 2 in.—300	5⅜ in.—36 2 in.—239	5½ in.—50 2¼ in.—240
Tubes, length	15 ft. 1 in.	15 ft. 0 in.	15 ft. 0 in.	15 ft. 6 in.	13 ft. 6 in.	15 ft. 3 in.
Heating surface, firebox	175 sq. ft.	214 sq. ft.	207 sq. ft.	216 sq. ft.	225 sq. ft.	232 sq. ft.
Combustion chambers	.....	.....	.....	.....	71 sq. ft.	.....
Tubes	2,841 sq. ft.	2,530 sq. ft.	2,530 sq. ft.	3,390 sq. ft.	2,359 sq. ft.	3,236 sq. ft.
Firebrick tubes	.....	27 sq. ft.	.....	29 sq. ft.	.....	30 sq. ft.
Total	3,016 sq. ft.	2,771 sq. ft.	2,737 sq. ft.	3,643 sq. ft.	2,655 sq. ft.	3,498 sq. ft.
Superheater	623 sq. ft.	654 sq. ft.	634 sq. ft.	844 sq. ft.	575 sq. ft.	945 sq. ft.
Grate area	55 sq. ft.	54.4 sq. ft.	58.6 sq. ft.	58.7 sq. ft.	94.9 sq. ft.	74.9 sq. ft.
Driving wheels, diameter	62 in.	55 in.	54 in.	57 in.	55½ in.	61 in.
Journals	10½ in. by 13 in.	Main 11 by 13 in. Others 9½ by 13 in.	Main 11 by 13 in. Others 10½ by 13 in.	11 in. by 13 in.	11 in. by 13 in.	Main 12 by 13 in. Others 11 by 13 in.
Engine truck wheels, dia.	33 in.	30 in.	30 in.	30 in.	33 in.	33 in.
Journals	5½ in. by 10 in.	6 in. by 12 in.	6 in. by 12 in.	6½ in. by 12 in.	7 in. by 11 in.	6 in. by 12 in.
Wheel base, driving	17 ft. ½ in.	16 ft. 4 in.	15 ft. 7 in.	16 ft. 0 in.	17 ft. 0 in.	17 ft. 6 in.
Total engine	25 ft. 9½ in.	25 ft. 1 in.	24 ft. 4 in.	26 ft. 0 in.	27 ft. 0 in.	27 ft. 3 in.
Total engine and tender	62 ft. 5⅛ in.	60 ft. 1½ in.	61 ft. 4 in.	60 ft. 11½ in.	63 ft. 11 in.	74 ft. 1¼ in.
Weight, on drivers	226,900 lb.	240,320 lb.	242,300 lb.	238,000 lb.	250,800 lb.	268,200 lb.
On truck	22,600 lb.	19,940 lb.	20,050 lb.	30,000 lb.	30,300 lb.	26,700 lb.
Total engine	249,500 lb.	260,260 lb.	262,350 lb.	268,000 lb.	281,100 lb.	294,900 lb.
Total engine and tender	431,000 lb.	404,060 lb.	410,000 lb.	425,000 lb.	462,000 lb.	565,000 lb.
Tractive effort	53,300 lb.	58,700 lb.	60,600 lb.	56,000 lb.	61,500 lb.	68,200 lb.

Annual Convention of the Fuel Association

Papers on Pulverized Coal, Feed Water Heaters and Individual Fuel Performance Records

WITH an attendance of approximately 200, the International Railway Fuel Association opened its thirteenth annual convention at the Hotel Sherman, Chicago, on May 24 and adjourned after the consideration of a heavy program on May 26.

Following the usual opening exercises the meeting was addressed by Samuel O. Dunn, editor of the Railway Age. An abstract of Mr. Dunn's address follows.

Present Railway Situation

BY SAMUEL O. DUNN

Speaking of the need for economy in the use of fuel, Mr. Dunn called attention to the fact that the total cost of railway fuel in 1920 was $675,000,000, an increase of $423,000,000, or almost 170 per cent since 1916, due largely to increases in price, a large part of which took place last year. Continuing, he said:

Since the end of 1920 there have been substantial reductions in the prices paid by the railroads for coal. It is clear, however, that further reductions must be secured in all their operating expenses, including the cost of fuel. The cost of fuel must be further reduced both by reductions in price and by the effecting of greater economies in its use. The effecting of greater economies in its use must be brought about by securing greater efficiency in the firing of locomotives and also by continuance of the installation of devices which result in less fuel being burned in proportion to the power produced.

Mr. Dunn then took up the general railway situation and briefly sketched the developments which have led up to the present condition of the railroads in the United States, most of which, in spite of the relatively high freight rates, have not been earning enough to pay their operating expenses and taxes since the new rates were fixed late in August last year. He then took up the question of reducing operating expenses, about which he spoke in part as follows:

In addition to seeking abrogation of the National Agreements, the railways have asked the Railroad Labor Board to make general reductions of wages. They base their application mainly upon the grounds that wages have been reduced in most other industries and that the cost of living has declined.

The principal answer of the labor leaders to this argument is that through mismanagement the railways are wasting about $1,000,000,000 a year, and that all this alleged waste should be eliminated before the payroll is curtailed.

After the present wages were fixed, and when the railways were still carrying a heavy traffic, their total operating expenses were running at the rate of about $6,000,000,000 a year, and of this amount almost $4,000,000,000 was going to labor in wages, leaving about $2,000,000,000 for other expenses. Since the labor leaders defend the present payroll, it follows, on their theory, that, by eliminating preventable "wastes" the managements could and should reduce all expenses except the payroll by almost 50 per cent. At least four-fifths of this other $2,000,000,000 of railway expenses consists of expenditures for fuel and for equipment and materials and supplies—iron and steel, lumber, office appliances, stationery, etc. The labor leaders claim the railways pay excessive prices for these things because the railways are under the same financial control as the concerns from which they make purchases.

It would be easy to prove, if time permitted, that all this talk about the control of railways and the concerns from which they make purchases by the same financial interests is the wildest buncombe. But suppose they are under the same control. Where is the evidence that this causes the railways to pay excessive prices for fuel and for materials and supplies? Do they pay more for coal than other large consumers? The coal operators complain loudly that the railways use the "assigned car" rule to get coal cheaper than other concerns. Do they pay more for iron and steel? Until recently they, like other consumers, were paying the United States Steel Corporation, which is supposed to be the archtype of a concern controlled by the house of Morgan, the same prices which were fixed by a government board in 1919, and which other people were paying; and they are now paying it and other steel concerns less than these prices. Do the railways pay more than others for lumber? Every lumber manufacturer and dealer will say they are close buyers. The allegation that the railways as a whole, because of their

J. B. Hurley (Wabash)
President

W. J. Bohan (Northern Pacific)
Vice-President

W. L. Robinson (B. & O.)
Vice-President

J. G. Crawford (C. B. & Q.)
Secretary-Treasurer

actual or alleged financial control, waste money by intentionally paying excessive prices, has never been supported by a scintilla of evidence, and it never can be, because it is absolutely baseless.

The labor leaders also criticise the railways for not having made certain important improvements in their physical properties which would enable large economies to be effected. To make large economy-producing improvements the railways must first raise large amounts of new capital to invest in them. But they cannot raise this new capital until they are enabled to earn a net return sufficient to pay reasonable interest and dividends on their present valuation. Their net return cannot be made adequate for this purpose without large reductions of their present expenses, of which the payroll constitutes two-thirds; and the labor leaders oppose all reductions of the payroll.

I have not the slightest idea that the pre-war wages of railway employees ever will be restored, nor do I think they ever should be. There were many classes of employees who, before the war, were not paid as much as they should have been in proportion to the cost of living at that time, and I hope to see their wages in future kept higher in proportion to the cost of living than they were before. And in this connection I think special reference should be made to the cases of supervisory officers. It is a fact today, as it has been for years, that many supervisory officers are paid less than the higher paid employees over whose work they exercise supervision. Indeed, the average salary of all division officers, including superintendents, master mechanics, trainmasters, road foremen of engines, etc., is less than the average wages of some employees. According to the latest available statistics the average salary of all division officers now average $3,437 per year, while the wages of passenger locomotive engineers average $3,450 and the wages of freight engineers $3,586. The advances granted to divisional and supervisory officers since before the war have been relatively much less than those granted to most classes of employees, and as a matter of justice to the officers this fact, together with the fact that many of the officers were underpaid before, should be given great weight in any readjustments which may be made in future.

Bad as the situation is today, I am not pessimistic about the future of the railways. On the whole, I have no doubt that we have seen the worst we are going to see in the railroad business.

However, we should clearly recognize the fact that if the railroads are again to be put upon their feet the utmost efforts must be made by all of us who are directly interested in the business, first, to secure the utmost efficiency and economy of operation, and, second, to keep the public fully informed regarding everything that is being done to promote efficiency and economy, in order that the many unjust attacks which will continue to be made upon the managements of the railroads in the future, as they have been in the past, will not mislead public opinion regarding private management. All of us who are in close touch with railway affairs know that private management is by no means perfect, but we all have very good reason for believing it is much better than government management or Plumb plan management would be, and, therefore, it is our duty to do all we can to make sure that private management will be perpetuated.

President Hurley's Address

Following Mr. Dunn's address, J. B. Hurley delivered the presidential address, of which an abstract follows:

The occasion that bids us gather in convention at this time is indeed an important and impressive one. Many great and perplexing questions confront the mind of America today and call for settlement—never probably in the history of the nation was there a time when loyal citizenship and patriotic co-operation on the part of all for the good of her institutions, for the maintenance of her business enterprises and for a respectable moral standard was more desired than at present. War with its horrors and sacrifices brought extravagance. The emergencies of the times to a great extent broke down our systems of economy and an extravagant increase in material, in production, in labor was a natural outcome of urgent necessity.

The war has ended, but it has left its impressions and its deadly influence—excessive profits and wages of war times have brought a spirit of unrest and discontent to the minds of those who in their loyalty are asked to practice economy that our business interests may prosper, that we may take our place even with keen competition, not only as the first nation of the world by our wealth, but first as an industrial and commercial nation. This is the prime object of our convention—that we may bring about a better feeling and spirit between employer and employee, that we may win the employee by interesting him in his work and making him feel that work is rather a pleasure than a crime—that we may better the employee by educating him to know and understand his work that he may do it well, and hence, be a source of satisfaction and interest to his employer, that by so working, the employer may know and understand that the work of the employee is of first interest to the employer and that he concern himself in working for and bettering the working and home comforts of his employees when consistent. A spirit of mutual interest between employer and employee is an absolute necessity if our business is to prosper and grow.

Report of Committee on Pulverized Fuel

The progress of the art of burning pulverized coal by railroads on locomotives or in stationary plants the past year has, on account of well understood economic and other conditions, been practically nil, no new installations having been made.

Some few tests have been made. One of these which is of some interest was made on Lehigh Valley locomotive No. 1360 between Easton and Lehighton, Pa., to determine the practicability of burning pulverized North Dakota lignite containing 15 per cent moisture and Red Lodge sludge (Montana sub-bituminous coal) without resulting in serious honeycomb formation or unusual disintegration of brick work.

The results were successful with the exception of the honeycomb formation which with either coal developed rapidly on the back flue sheet when the locomotive was worked hard and seriously hampered operation. The committee suggests that this honeycomb formation be not taken too seriously and believes that with proper research and engineering work to determine the coal characteristics and to develop proper design of boiler and firebox with particular reference to combustion area and also to drafting, that this problem can be solved. In connection with drafting the committee has in mind the elimination of pulsating draft and correctly determined air supply.

In stationary practice two new cases of pulverized coal operation have been called to the committee's attention. The Milwaukee Electric Railway & Light Company during the past year completed and put into operation a new power plant at St. Francis, near Milwaukee, Wisconsin, manifesting their confidence in the economic advantages of burning pulverized coal.

The Oklahoma City plant of Morris & Company, originally equipped with chain grates, has been modified to burn either pulverized coal or oil and has been in successful operation for a little over a year. By the use of suitable burners it is practicable to burn either pulverized coal or oil without changing furnace or boiler. The coals used are McAlester Field having a B. t. u. value of 10,000 to 11,500; moisture, 5 to 10 per cent; volatile matter, 20 to 30

per cent; fixed carbon, 40 to 45 per cent; ash, 30 to 35 per cent; sulphur, 1 to 2 per cent, and Texas lignite having a B. t. u. value of 6,000 to 7,000; moisture, 30 to 35 per cent; volatile matter, 20 to 25 per cent; fixed carbon, 25 to 30 per cent; ash, 10 per cent.

This plant is reported as being particularly economical in cost of operation, showing an 8 to 10 per cent saving in cost of steam production on McAlester coal, over the stoker fired boilers burning coals of equivalent B. t. u. values. Accurate daily records of cost are maintained for comparison.

The state of the art today indicates an unquestionable field for pulverized coal and that its commercial use depends upon the economic conditions obtaining, each case requiring its own particular analysis.

The committee repeats its previous recommendation that thorough research and engineering work accompanied by conclusive tests be conducted at one of our universities adequately equipped, particularly for burning of pulverized coal on locomotives, the work to be supervised by competent men representing the railroads and the university.

The report is signed by W. J. Bohan (Nor.-Pac.), chairman; H. T. Bentley (C. & N. W.); R. R. Hibben (M. K. & T.); H. Piollet (Lehigh Valley); W. G. Squires (N. Y., N. H. & H.); J. M. Nicholson (A., T. & S. F.); L. R. Pyle (Locomotive Firebox Co.); W. L. Robinson (B. & O.), and E. C. Schmidt (North American Co.).

Discussion

Alonzo G. Kinyon (Fuller Engineering Company) expressed the opinion that it would not be many years before as high as 50 per cent of the coal burned would be in a pulverized form, this statement applying particularly to industrial and power plants. He said that the locomotive, as at present designed, was not well adapted to burn pulverized coal under all of the conditions it is called on to meet. Thus far nothing has been developed which will eliminate trouble from honeycombing, with certain coals when the locomotive is working at high capacity.

Eugene McAuliffe said that it is yet to be proved whether a kilowatt-hour is produced with fewer heat units from pulverized coal than from coal burned on grates, but laid stress on the versatility of pulverized fuel burning equipment where relative values of oil and coal call for frequent changes from one to the other.

Locomotive Feed Water Heating

The interest in feed water heaters in America is shown by the history of the past year to be growing, in that the number of roads to take up types of feed water heaters for tests has increased. There are no new feed water heaters brought out this year, but progress has been made in the simplification of the design of the Locomotive Feed Water Heater Company and Worthington systems.

In 1920 there were seven roads using the Locomotive Feed Water Heater Company, Weir, Worthington, Caille, and the Simplex Blake-Knowles feed water heaters. There are now eighteen American roads with five types of heaters on order or in service; namely, the Locomotive Feed Water Heater Company, Weir, Worthington, Caille, and the Simplex Blake-Knowles. These are as follows:

The Superheater Company's Feed Water Heater:	
Delaware & Hudson	2
New York Central	4
Delaware, Lackawanna & Western	1
Ft. Smith & Western	2
Grand Trunk	1
Erie Railroad	5
Canadian Pacific	1
New York, New Haven & Hartford	5
Atchison, Topeka & Santa Fe	2
Southern Pacific	4
Central Railroad, New Jersey	1
Central Vermont	2
Chicago & North Western	2
Lake Shore & Michigan Southern	1
Elgin, Joliet & Eastern	2
Total on order and applied	35
Worthington Feed Water Heater:	
Pennsylvania Railroad	4
Norfolk & Western	1
Southern Pacific	5
Chicago & North Western	2
Total on order and applied	12
Weir Feed Water Heater:	
Canadian Pacific	1
Southern Railway	2
Grand Trunk	1
Total on order and applied	4
Caille Feed Water Heater:	
Baltimore & Ohio	1
Simplex Blake-Knowles Feed Water Heater:	
Erie Railroad	3

The Southern Pacific is trying out some of both the open and closed types of heaters. The roads which have tested out these heaters are securing practically the same results as given in the results of tests of the two classes of heaters, a saving of between 13 and 15 per cent based on increase in evaporation of pounds of water per pound of oil. However, in bad water districts it has been found necessary to clean the closed heaters due to scaling, in order that this saving be maintained. No data are available in bad water districts of the Worthington heater. Several means have been tried for the cleaning of the closed type of heaters, and it is believed that satisfactory means at low cost have been secured using a dilute solution of hydrochloric acid, but service alone can determine the life of the feed water heaters and flues.

The question of weight on drivers has to a certain extent influenced the adoption of the feed water heaters as at the present time the railroads have this problem to contend with, and in order to keep the weights of the locomotives within the bounds prescribed by their various roads, this valuable method of saving fuel has not been universally adopted.

The report is signed by E. E. Chapman (A. T. & S. F.), chairman; E. A. Averill (The Superheater Co.); O. S. Beyer, Jr.; B. J. Farr (Gd. Tk. Wn.); F. Kerby (B. & O.); A. T. Pfeiffer (N. Y. C.); L. G. Plant (Ry. Review); L. R. Pyle (Locomotive Firebox Co.), and W. H. Winterrowd (Can. Pac.).

Discussion

Eugene McAuliffe expressed the opinion that feed water heating had proved an effective means of reducing fuel consumption and the application of such devices is now only a question of obtaining the necessary capital.

J. N. Clark (Southern Pacific) described the results of feed water heater tests which showed that in some cases the heaters raised the temperature of the water up to 255 deg. F. He stated that the maintenance of the heater needs to be carefully considered, especially in bad water districts where it requires frequent cleaning because the savings largely disappear when scale forms on the surfaces.

E. E. Chapman stated that the saving in various tests range from 8.4 to 16.6 per cent. He pointed out that feed water heaters reduce the rate of combustion and thus lengthen the life of boiler tubes and firebox sheets. It has been found advisable on the Santa Fe to clean the heaters every two weeks with a diluted solution of muriatic acid. This operation requires about two hours and is effective in removing scale.

Standards of Fuel Economy

D. C. Buell, director, Railway Educational Bureau, presented a paper on this subject, in which he gave a comprehensive outline of the steps which must be taken before ideal results can be secured in any campaign for the economical use of railway fuel.

Starting with the executive, Mr. Buell took up the essential requirements of a fuel conservation policy, and outlined the matters for executive attention in the purchasing, operating and mechanical departments. The conditions which require the attention of the supervisory forces were then enumerated for all departments concerned, including fuel inspection, operating requirements, the important points for

attention in the shops and roundhouse and the points requiring special attention by the road foreman.

Referring to the 78 points enumerated, he said in closing:

"There is hardly an item in this entire list which has not been a subject for a paper or for discussion at some of the conventions of the International Railway Fuel Association. Those who have been members of this Association for a number of years have their file copies of proceedings which can be referred to in order to check the methods presented to this Association by practical fuel men, which have proven successful in dealing with these numerous problems.

"Those who have only recently become members of the Association can obtain back copies of the proceedings of the last few years from the secretary for a nominal sum.

"The problem of fuel economy is just as much a science as any other of the engineering problems, and it is only through a careful study and analysis of individual problems that an officer whose duties involve a responsibility for fuel economy may hope to obtain satisfactory results. Therefore it is urged upon the members of this Association that our proceedings be used as a reference library to be referred to and studied, in order that they may become more proficient in this branch of our American transportation problem.

Discussion

Harrington Emmerson briefly sketched the history of the development of the use of steam power from the first crude steam engine when there was no quantitative measure of the energy in the coal at one end or of the work performed at the other, through the steps that finally led to the present knowledge of steam engineering which makes possible a definite determination of the efficiency of the application of fuel to the production of work. He concluded that what was necessary in the efforts of the railways in fuel conservation were similarly definite standards of fuel consumption in relation to ton-mile output so that the success of fuel economy programs could be definitely measured.

In closing the discussion Mr. Buell stated that in developing and correlating the various factors in a complete plan for fuel economy, he had followed the principle of dependent sequences developed by Harrington Emmerson in his paper presented before the association at the 1915 convention. Mr. Buell also acknowledged the importance of definite standards under present conditions, since the public has a right to inquire as to the efficiency with which the railroads are managed and operated and the railroads cannot afford to be without some such standards, the absence of which will indicate to the public a lack of knowledge of the fundamentals of their own business.

Value of Individual Fuel Performance Records

BY ROBERT COLLETT
Superintendent Fuel and Locomotive Performance,
New York Central

There have been presented before this Association several papers outlining the practice on various railroads where individual fuel records have proved valuable and which in some instances continue in force. A reasonably thorough canvass, however, discloses that such records are by no means standard practice on American railroads, chiefly, it seems, for the reason that the general method of determining individual coal charges to locomotives is largely guesswork. The value of any record lies in what we get from it and depends on the good or bad opinion of those who live with it. Mr. McAuliffe once aptly said: "I have been connected with a dozen different kinds of fuel performance records not one of which was absolutely correct, but the worst was better than none at all."

Railroad officers fully appreciate the need of knowing, first, about how much fuel is required for a given service, and secondly, how much is being used. How best to get this information depends chiefly on local conditions. With present day facilities on the average railroad it is not possible to present to an engineman or fireman a bill, so to speak, for a certain amount of fuel burned for which he is responsible, since all of the old handicaps of delays, light mileage, etc., over which he has no control, are still with us and added thereto are complications such as changing firemen, pooled engines, no means of measuring coal, and so on.

The engine record seems the best as a rule, save for oil-burners under certain favorable operating conditions, and this plan now predominates. The average cost of compiling such a record proves to be from one-half to one cent per ton of coal used. It is not usually intended as a check against the total fuel consumed, but to keep interest aroused. Grouping selected runs and showing only representative trips and not necessarily the total mileage or total fuel consumption for the month, has met with success on certain roads. The value of a fuel record also depends on how it is handled with the engine crews and departments responsible.

There are individual records which may be of value, although not elaborate. On the New York Central Lines East, we have made a great many trip records of fuel consumption and given considerable publicity on the road to these reports in an effort to apprise all concerned of what is considered good performance. Also, through various records of observations we attempt to check conditions affecting fuel costs, which include locomotive operation, quality and distribution of fuel, locomotive conditions, transportation matters, and lubrication. One reason for including the latter is the claim so often made that oil is often saved at the expense of fuel. These individual observations are made in company with a division officer and matters are handled on the ground, in preference to writing letters. The idea is not so much to improve the individual waste as to have conditions right on the division and the railroad as a whole.

We give each division officer, including traveling firemen, what we call a bill of expense each month for the fuel burned in each class of service, the unit consumption, and the total cost. We also show this in "Cost per 1,000 Locomotive Miles." One reason for this is to compare the relative cost of fuel with other items which may have received no more attention than they deserved, but relatively far more attention than the fuel costs. On the enginemen's bulletin boards we post a statement of miles run per ton of coal in each class of service, with a foot-note showing the number of scoops used per mile and what a small saving would amount to. We find the men like this even better than the gross ton-mile statements, although we post them also. Recently, we have been posting at some of our terminals the coal charges as shown by our daily report of disbursements, which shows the engine number, to which we have added the train number. Of course, it gives the crews an opportunity to criticise our coal estimates, but it creates interest and makes us careful in our estimating.

If we get individual effort collectively applied and concentrated on ways and means to encourage pride in having our railroad the best in fuel performance, it matters not so much what kind of records we have. If our records give individuals credit and commendation where due, and point out to all departments and individuals in a co-operative spirit what we are doing, what it is possible to do and in some small way at least how to do it, we will have two fuel supervisors on every engine and one in every office.

I believe in an individual record and a daily check of the coal burned, so far as practicable, against the ton miles or passenger car miles for the education and interest it affords to those who follow fuel economy and who use fuel. But no record ever taught a man how to fire or run an engine more skilfully than he already knew. We certainly need and in time will have better and more fuel records on American railroads, but where successful, under present coaling arrangements, they will not attempt to stress individual lia-

bility so much as they will the possibilities of concerted effort.

Discussion

J. G. Crawford (C. B. & Q.), presented a written discussion from which the following is taken:

In 1917 a committee consisting of an assistant auditor, fuel distributor, inspector of stores, traveling accountant, engineer of tests and myself were appointed to investigate fuel accounting. The accounting necessary in connection with the "Daily and Monthly Enginemen's Fuel Performance Statements" influenced the fuel accounting to a considerable degree, and the first work of this committee was to find out what use was made of them and to estimate their value.

The committee assumed that the reports were for the following purposes:

(1) To create interest among enginemen which would result in a more economical use of locomotive fuel.

(2) To give master mechanics and road foremen a statement which they can use to determine the relative standing of the enginemen so that they can urge, require and demand improvement of those whose performance is below what it should be.

(3) To give superintendents of motive power and other general officers a summary of the effects of fuel economy efforts.

Twelve division points and two important terminals were visited. Master mechanics, road foremen, engineers and firemen were interviewed. Bulletin boards and bulletin books were examined to ascertain the manner and date of posting these statements. About one-half of the eighteen divisions were found to be making out the daily statement.

All divisions compiled the monthly statement. This could not be avoided, because the monthly statements from each division were consolidated into a system statement. Of the twelve division points visited only eight had the monthly reports posted. Some of these had not been sent to roundhouses for posting for over a year and one was being put in the waste basket by the roundhouse clerk. Only five division points had made out and posted the daily reports. One division did not figure the pounds of coal per switch hour, per passenger car mile or pounds per hundred ton miles or the average speed. In some cases the daily reports were carbon copies, made with pencil instead of typewriter, and were not readable.

The daily reports were posted too late to be of any value. It was originally intended to post these within 48 hours after the day covered by the report. The monthly reports were posted about three weeks after the end of the month. At one point where there are ten bulletin files the four last monthly reports were on three different files.

Of 122 engineers and firemen interviewed, 51 stated they did not examine the statements and 66 said they did occasionally, but they could not tell their approximate standing.

Of nine master mechanics interviewed eight did not use the reports and recommended discontinuance, one said it was one of the most important reports.

Eight road foremen were interviewed, of whom six did not use the reports and recommended their discontinuance, while one used and recommended discontinuance, and one used and made no recommendation as to discontinuance.

These reports were discontinued.

On any railroad there are a large number of engineers who are as conscientious and as capable as the officials who supervise them. This class does not need much supervision and an inaccurate individual fuel performance record is of no value in bringing about greater fuel economy in their case. There is a second group of men who are as conscientious, but not as capable and could be appealed to through an accurate statement, but not through one which is inaccurate. The third class as I see it is not conscientious; is subdivided between both capable and incapable. This class, though small in number, requires an excessive percentage of the road firemen's time. Something could be done with this group if an accurate individual fuel performance record were available, but an inaccurate record is of no value.

It seems to me that the smallest unit on which to base a fuel performance record, is the division until such time as an accurate record of the coal used by each engineman is obtainable. The statement using the individual engine as the unit is slightly more accurate than the statement using the engineer or the fireman as the unit, as there are a lesser number of engines than engineers or firemen. However, the principal advantage of making an individual engine fuel performance record in place of an individual engineman's fuel performance record is that the engines cannot talk back and tell you how inaccurate is the statement.

Nothing herein should be construed as not advocating working on the individual engineer and individual fireman to obtain the greatest fuel economy, but working through the medium of an inaccurate individual engineman's performance record is not advocated and should be discouraged.

Other Papers

A number of other papers and reports were also presented, including committee reports on the Storage of Coal, Fuel Accounting, and Firing Practice. The individual papers included Fuel Conditions on French Railways, by M. de Boysson, chief of locomotive service, Paris-Orleans Railway; Fuel Economy—A Few Essentials, by Carl Eduard Uddenberg (State Railways of Sweden); Preparation and Distribution of Fuel, by C. E. Bast, fuel engineer, Delaware & Hudson; Fuel Department Organization, by L. G. Plant, (Railway Review); Oil Shale as a Source of Oil Supply, by Martin J. Gavin (Bureau of Mines); Cost of Production of Coal, by Mont B. Morrow (Canmore Coal Company, Ltd.); and Report on Briquettes and Sub-Normal Fuels, E. E. Ramey (B. & O.), chairman.

Other Business

Eugene McAuliffe (Union Colliery Company) in an address before the association, called attention to the lack of co-ordination between the carriers and the coal industry, although the movement of coal constitutes approximately 37 per cent of the gross ton-miles of freight movement and the railroads purchase from 25 per cent to 28 per cent of the bituminous coal production. He advocated the establishment of seasonal freight rates on coal as a means of effecting a better local factor on both the mines and the railroads.

One of the features of the meeting which received favorable comment on several occasions was the presence of eight engine crews, one from each division of the Atlantic System of the Southern Pacific. These men, who had had the best fuel records on their respective divisions during the previous three months, were sent to the convention by the management as a mark of recognition for the results they have obtained in their efforts to save fuel. This is a part of the newly developed plan of division fuel committee organization on the Southern Pacific System.

During the convention Harrington Emmerson distributed to the members copies of a summary of the Interstate Commerce Commission railway fuel report for 1920 which he had prepared showing the costs of the various kinds of fuel on an equated heat unit basis.

On recommendation of the Committee on Constitution and By-Laws, the annual dues of the association were raised $1 a year.

The following officers were elected for the coming year: President, W. L. Robinson (B. & O.); vice-presidents, J. N. Clark (Southern Pacific), M. A. Daly (Northern Pacific), and W. J. Bohan (Northern Pacific); members of the Executive Committee: H. T. Bentley (C. & N. W.), D. I. Bergin (Wabash), C. M. Butler (A. C. L.), J. W. Dodge (Illinois Central), Joseph Keller (Lehigh Valley), and Hugh McVeagh (Big Four).

Chicago was chosen as the place for the next convention.

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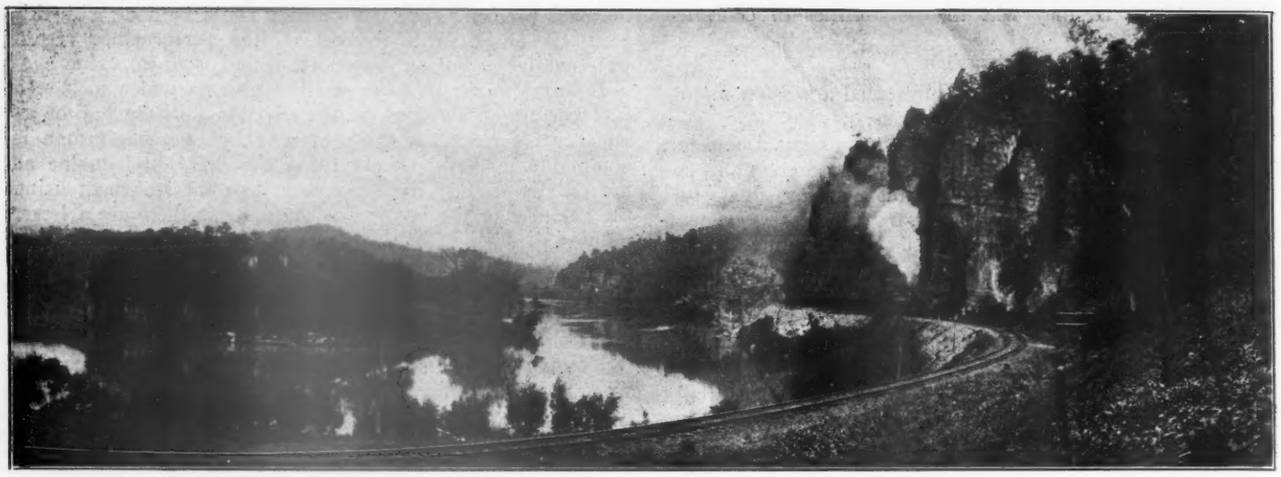


The 100-Car Demonstration Train Rounding a Curve on the New River

Virginian Demonstration of Double-Capacity Brake

Train of 16,000 Tons Handled Down 1.5 Per Cent Grade; Close Speed Regulation—Low Air Consumption

ALL records for the operation of a heavy train down a long grade were shattered on May 25, when there was handled from Princeton, W. Va., eastward to Roanoke, Va., on the Third district of the Virginian Railway, a train of 100 loaded 120-ton cars of coal aggregating 16,000 gross tons. This train was a test train run to demonstrate what could be done with the new 120-ton cars and the double capacity brakes used by the Virginian Railway. It marks the latest step in the progress towards heavier train loading which has characterized the operations of the Virginian since its inception.

The Virginian Railway's theory of operation is stated in the following words: "The more loads you haul in one trip the less trips you'll have to make." The road was built with that idea in mind. Today the company is operating with the largest capacity equipment and most powerful locomotives which are in service in this country and therefore in the world. The success the road has been having in working out its scheme of operation is attested by the fact that the road is hauling in regular service trains of 90 to 100 loaded cars aggregating 8,000 to 9,000 gross tons. The average net tons per train—the figure which includes all freight trains of whatever kind—in 1920, totaled 1,800, the largest for any road in the country.

Westinghouse Double Capacity Brake

The double capacity brakes as applied on the Virginian 120-ton cars represent the latest development of the Westinghouse Air Brake Company's equipment for long trains of extremely heavy cars. Some time previous to the introduction of the 120-ton car, the road had consulted the air brake company with regard to handling still greater tonnage by operating 90 or more 55-ton cars per train. This brought up the question of applying a special brake with a double capacity feature, the KCE 10-10, which had already been developed in anticipation of a demand for heavy-tonnage operation that would necessitate the use of a brake providing a more uniform breaking ratio, lighter retardation on empty cars with a substantial reserve braking force available in the case of loaded cars.

Eleven hundred of the 55-ton cars of the type then in use were equipped accordingly with the double capacity feature. The results were so gratifying that the Virginian saw the possibility of extending the use of such apparatus to cover the requirements of much heavier rolling stock.

It was early developed that to secure the required results, it was necessary to put in a train cars with the empty and load brake to the amount of 15 per cent of the total train—in other words, 15 cars in a total of 100. At first it was thought necessary to keep the empty and load brake cars at the front of the train. This was later found to be unnecessary, so they are now distributed throughout the train as they happen to come, the only requirement being to get the 15 per cent empty and load brake cars.

During the spring and summer of 1914, the advisability of increasing the capacity of the individual car was suggested with the object of not only increasing the tonnage of the train, but at the same time decreasing its length. This suggestion resolved itself into the 120-ton capacity car. The Virginian ordered the construction of the cars on the assurance of the Westinghouse engineers that the first double capacity brake had been further developed to a point that would meet the requirements of the heaviest car that any railroad could conveniently handle from the standpoint of motive power.

The problem of providing the proper brake equipment for these record-breaking cars was solved by minor modifications in the double capacity equipment, which had already been brought to a high degree of development in anticipation of a demand for freight brakes of exceptionally high capacity. It is significant of the well-rounded development of the air brake art that the conditions to be met on the Virginian involved only one new factor, the high ratio of loaded weight to the light weight of the car. The grades presented no special difficulty since trains are being handled daily with air brakes alone on much steeper gradients. The length of the train was no greater than has been successfully handled with the existing equipment and the total weight of the train is of secondary importance since each additional unit increases the braking force correspondingly.

The principal problem in braking these heavy cars, as already stated, was to provide a suitable ratio of braking force

to car weight, both loaded and empty. The equipment as finally applied and demonstrated between Princeton and Roanoke is known as Schedule KDE-4-10-16, indicating that three cylinders, whose diameters are represented by the figures, are employed. A change-over valve and a load reservoir are used to provide the flexibility in braking force which makes it possible to obtain a uniform braking ratio in solid trains of loads, solid trains of empties, or mixed trains. The cylinders in load operation augment each other in such sequence that only a short piston travel is required in each case, making for practically normal air consumption, though providing a much greater braking force than is obtainable with the standard single capacity brake. The relative braking force and air consumption of the double capacity brake and various types of single capacity equipment are clearly shown in one of the diagrams.

Operation of the Brake

The fundamental characteristic of the double capacity freight brake equipment is that it provides for the same percentage of braking force (ratio of total shoe pressure to car weight), on a loaded car as on an empty car.

With the single capacity brake the braking force developed is constant in magnitude but varying in its relation to the car weight. Consequently, it is much less effective on a loaded car than on an empty car. The usual practice has been to so design the brake layout as to provide the highest practicable percentage of baking force on the empty car, 60 per cent being the standard for freight cars, and then to accept whatever reduced braking ratio might be available for the loaded car. This means that in grade service the retarding force on a loaded train may not be adequate for safe control, and in level road service the retarding force may vary so much throughout a mixed train as to be productive of damaging shocks. Furthermore, in long trains of empties, severe shocks are often created because of the high braking ratio, which manifestly cannot be lowered if any appreciable braking force is to be realized on a loaded car, and also because of the inherent serial action of a purely pneumatic brake.

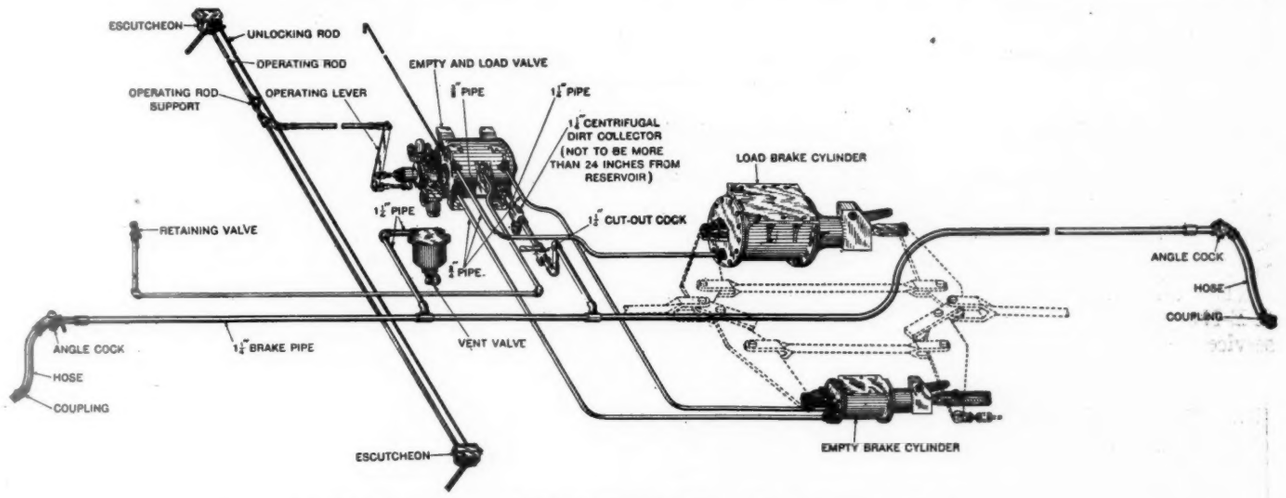
In the effort to mitigate these undesirable effects, various expedients are sometimes resorted to which are far from satisfactory, and restrictions are often imposed on train make-up and operation which tend to curtail traffic.

Obviously the ideal condition is that in which the braking force on loaded cars bears the same relation to the loaded weight as that on the empty car bears to the light weight, so that adequate and uniform retardation may be possible.

The ideal condition, always desirable, becomes imperative with heavy tonnage trains made up of high capacity cars, because of the great difference between the loaded and empty car weights. In other words, the operating conditions of loaded and empty trains with modern equipment are so widely separated that any attempt at a compromise between the two will result in unsatisfactory operation with either one or the other. The degree of retarding force set up on an empty car must be such as to permit a train of empties to be handled without the possibility of unduly severe shocks. On the other hand, with a loaded car a degree of retarding force must be provided which will be adequate to control safely a loaded train down a grade. These two requirements are so far apart that a solution of the problem is possible only with a *double capacity brake,* one which will be equally as effective when the car is loaded as when it is empty.

With the double capacity brake equipment the brake layout is designed to provide for 40 per cent braking ratio as against the usual 60 per cent for an empty car (permitting smoother brake operation on long trains of empty cars), and also 40 per cent for the loaded car as against the usual average of 15 per cent.

The equipment, known as schedule KDE-4-10-16, has three brake cylinders of the size indicated by the numerals. They are the take-up cylinder, the empty cylinder and the load cylinder respectively. In addition to the usual auxiliary reservoir there is a small load reservoir provided to supply the additional air required for loaded car braking.



General Arrangement of Double Capacity Brake Equipment on the Car

When the equipment is set for empty car operation, the take-up and empty cylinders, which are built into one structure with the small piston operating within the larger, operate as one 10-in. cylinder similar to the standard single capacity brake. When the equipment is set for loaded car operation the take-up cylinder piston first takes up the slack in the rigging and brings the shoes firmly against the wheels. Then the empty cylinder piston moves out a slight amount, its clutch gripping the notched push rod of the take-up cylinder piston, thus supplying additional force. Finally, as the brake pipe reduction continues, the load cylinder piston moves out a slight amount, gripping its notched push rod and adding to the force already developed, through the connecting rods and levers. By this method of slack take-up and short travel of the larger pistons the volume of air required for a given application is reduced to a minimum. In addition, especially where retaining valves are used, after the first reduction required to bring the load cylinder into operation (about 12 lb.), all succeeding reductions are much lighter, and consequently the air consumption is more economical than with any other form of equipment for a corresponding degree of

train control, and still within the capacity of the standard 1¼ in. brake pipe—an important requirement.

The higher braking ratio necessary for the loaded car can only be obtained when desired, since the equipment is manually changed for loaded car braking, through the medium of an operating mechanism which shifts a change-over valve to its load position. This valve functions similarly to a number of cut-out cocks to effect the proper volume and port arrangements, and also controls the flow of air to the cylinders in the proper sequence.

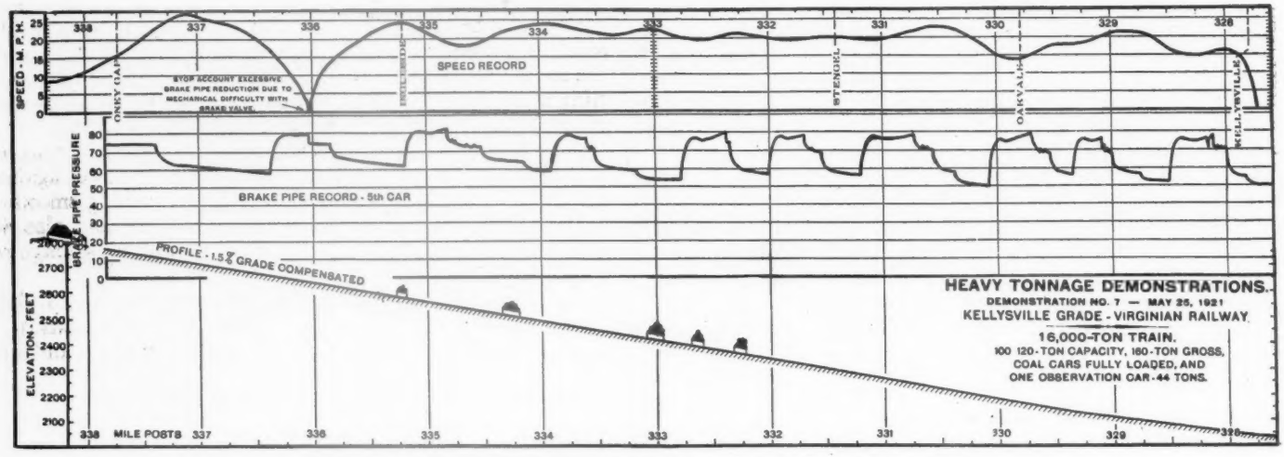
The equipment may be manually cut into empty position again, or if this is not done, it will automatically return to empty position when the pressure in the system leaks down to about 15 lb., as would be the case, for example, when the car is being unloaded on a siding.

The triple valve used with this equipment (designated the K-E-N), possesses the same essential characteristics of quick service, uniform recharge and uniform release as are embodied in the well known K type of valve now in general service. A separate quick action device in the form of a brake pipe vent valve is employed.

Attention should be called to the fact that the unit system, fundamental to all brake equipment now in use on freight cars, is preserved with this new equipment, so that if there be excessive brake cylinder leakage on one car it affects that car only and does not interfere with the proper operation of the remaining brakes in the train. This feature insures the desired flexibility and safety of brake control.

Handling a 16,000-Ton Train Down 1.5 Per Cent Grade

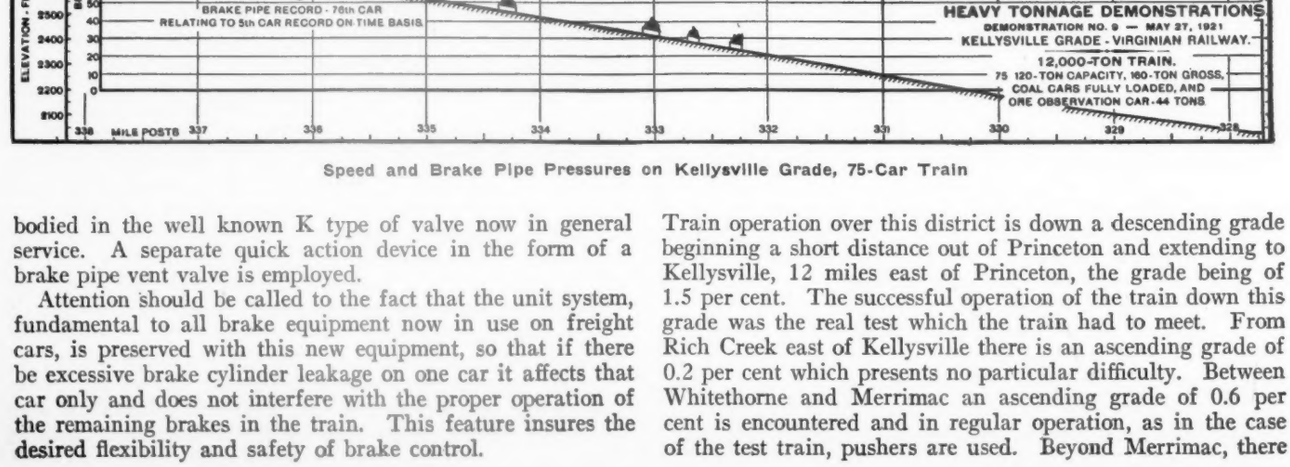
The impressive run—the peak of heavy train operation on any railroad—which was made on the Third district of the Virginian on May 25, presumably sets a record in heavy train loading which will not be again reached for some time. On that day a train of 100 of the new 120-ton gondola cars, each loaded to its full capacity, making an aggregate train load of approximately 16,000 gross tons, was successfully handled both on the heavy grades and on the comparatively level sections between Princeton and Roanoke. This train was handled with one of the Virginian, Class 800, AE 2-10-10-2 Mallet locomotives at the head end.


SPEED - M.P.H.
SPEED RECORD
BRAKE PIPE RECORD - 5th CAR
PROFILE - 1.5% GRADE COMPENSATED
ELEVATION - FEET
MILE POSTS
HEAVY TONNAGE DEMONSTRATIONS.
DEMONSTRATION NO. 7 — MAY 25, 1921
KELLYSVILLE GRADE - VIRGINIAN RAILWAY.
16,000-TON TRAIN.
100 120-TON CAPACITY, 160-TON GROSS,
COAL CARS FULLY LOADED, AND
ONE OBSERVATION CAR-44 TONS.

Speed and Brake Pipe Pressures on Kellysville Grade, 100-Car Train

The AE Mallets are the largest locomotives in service on any railroad. They have a total weight in working order, including engine and tender, of 898,300 lb. Working simple, they have a tractive effort of 176,000 lb. and compound, 147,200 lb. The Virginian owns 10 of them.

The distance from Princeton to Roanoke is 97.2 miles. Train operation over this district is down a descending grade beginning a short distance out of Princeton and extending to Kellysville, 12 miles east of Princeton, the grade being of 1.5 per cent. The successful operation of the train down this grade was the real test which the train had to meet. From Rich Creek east of Kellysville there is an ascending grade of 0.2 per cent which presents no particular difficulty. Between Whitethorne and Merrimac an ascending grade of 0.6 per cent is encountered and in regular operation, as in the case of the test train, pushers are used. Beyond Merrimac, there


SPEED - M.P.H.
SPEED RECORD
BRAKE PIPE RECORD 5th CAR
PROFILE - 1.5% COMPENSATED
BRAKE PIPE RECORD - 76th CAR
RELATING TO 5th CAR RECORD ON TIME BASIS
ELEVATION - FEET
MILE POSTS
HEAVY TONNAGE DEMONSTRATIONS
DEMONSTRATION NO. 9 — MAY 27, 1921
KELLYSVILLE GRADE - VIRGINIAN RAILWAY.
12,000-TON TRAIN.
75 120-TON CAPACITY, 160-TON GROSS,
COAL CARS FULLY LOADED, AND
ONE OBSERVATION CAR-44 TONS

Speed and Brake Pipe Pressures on Kellysville Grade, 75-Car Train

is a short descending grade of 1.5 per cent, followed by descending grades of 0.9 per cent and of 0.6 per cent into Roanoke.

Test Demonstrates Train Load Limit Not Reached

The project of handling this long and heavy train over this particular district was undertaken with the idea of demonstrating that the limit for train loading has not yet been reached and also to observe, in actual service, the new Westinghouse double-capacity brake with which the cars are equipped. During the run to Roanoke, records of the brake performance were made by means of recording instruments on the locomotive, on the fifth car and on an observation car

Train Ready for Standing Tests

at the rear end of the train. The speed of the train was also shown by speed indicators installed in the observation car.

To start the loaded train at Princeton, three eight-wheel switching locomotives were used as pushers, these being dropped when the train had reached a speed of 12 miles an hour. A 2-8-8-2 Mallet pusher was also used from Rich Creek to Merrimac, over the 0.2 per cent grade to Whitethorne and thence up the 0.6 per cent grade from Whitethorne to Merrimac. The start at Princeton was made smoothly. The run down the 1.5 per cent grade from Princeton to Kellysville was made at a speed of 20 to 27 miles an hour under control at all times. Due to the long and heavy train it was necessary to put a pusher on at Rich Creek instead of at Whitethorne as is done in normal operation. The pusher was dropped at Merrimac. From Merrimac to Fagg down the short stretch of descending 1.5 per cent grade, the train was handled at a speed of from 20 to 30 miles an hour, and from there on to Kumis and Roanoke at 15 to 20 miles an hour. During the trip the train had two break-in-twos due to defective knuckles and to the fact that the engineman was not familiar with so heavy a train.

Standing Tests

Before starting on the run to Roanoke a thorough inspection of the train was made and every precaution taken to have the cars and brakes in good condition. In order to insure proper action of the brakes, and also to demonstrate the special features of the empty and load brake to the railroad men and other engineers and observers who were present, a number of standing tests were made in the yard at Princeton. For the purpose of making these standing tests, the train was parted at the middle, the two parts placed on adjacent tracks, and the brake line connected up so that the front and rear ends were brought near together where both the start and finish of the brake action might be observed. These tests included an emergency serial action of the brake which was completed in 7.5 seconds; a quick service serial action in 13.9 seconds; and an emergency action in 8 seconds after the completion of a heavy service application. The value of such a brake performance, particularly in the severe service on the Virginian, will at once be apparent to men familiar with train operation. Demonstrations were also made of the operation of the take-up cylinders; the operation of the brake under both empty and load conditions; and the automatic return from load to empty position.

As the cars were assembled for the standing tests the train brake pipe, exclusive of the branch pipe and locomotive and tender, measured 4,097 ft. on the 70 car train, and 5,837 ft. when the additional 30 cars were later cut in.

No. 1—10-Pound Service Application—Brakes in Empty Position

The time from brake valve movement to piston start on Car 70 was 13.9 sec.; the rate of quick service propagation, 294 ft. per sec., or 201 m.p.h. The resultant cylinder pressure on Car 1 was 35 lb. and on Car 70, 25 lb. The time from movement of the brake valve to full release position to start of release on Car 70 was 10.5 sec.

No. 2—Emergency—Application—Empty Position

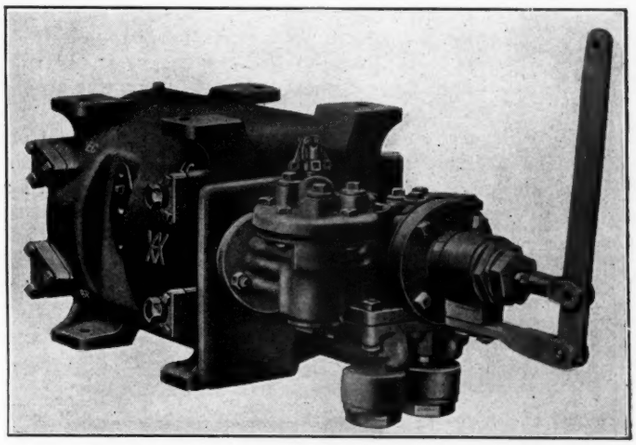
Time from movement of brake valve to emergency position to piston start on Car 70, 7.5 sec.; rate of emergency propagation, 546 ft. per sec., or 372 m.p.h. The resultant cylinder pressure on Car 1 was 54 lb., on Car 70, 51 lb.

No. 3—Emergency After Service Application—Empty Position

Service pressure in pounds, Car 1, 36; Car 70, 19. Service time in seconds, 13.8. Emergency pressure in pounds, Car 1, 53; Car 70, 50—time, brake valve to Car 70, 8 sec.

No. 4—To Illustrate the Double Capacity and Air Economizing Features

It was demonstrated that the brake cylinders, operated in the intended sequence, as follows, take-up cylinder, empty



Double Capacity Brake Equipment; Triple Valve Change Over Valve and Two-Compartment Reservoir

cylinder and load cylinder on application and in reverse order on release. The time from movement of brake valve to start of release on Car 70 was 21 sec.

No. 5—Automatic Return to Empty Position

The return to empty position occurred on Cars 1 and 70 when pressures were between 15 and 10 lb.

After the completion of Demonstration No. 5 the train was increased to 100 cars by adding 15 cars to each of the strings.

No. 6—Brake Cylinder Leakage

Cocks having No. 8 drill (.199 in. diameter) orifices were opened on five cars adjacent to Car 70, preventing the

development of brake cylinder pressure on those cars, while normal pressures were developed in the remainder of the cylinders.

That this intended brake cylinder leakage did not influence the pressure in the brake pipe is evidenced by the fact that while Demonstration No. 6 was in progress the brake pipe leakage was determined and found to be 5 lb. in two minutes from 61 lb. pressure.

SPECIAL DEMONSTRATION A (REQUESTED)

BRAKE PIPE LEAKAGE CORRESPONDING TO BRAKE CYLINDER LEAKAGE OF DEMONSTRATION NO. 6, ESTABLISHED STEP BY STEP ON CARS IN REGION OF CAR 70

No. Orifices (No. 8 Drill) Open	Brake Pipe Pressure		Brake Cylinder Pressure
	Car 1	Car 100	Car 100
None	69	66*	
1	69	60	†
2	66	47	46
3	65	41	46
4	64	30	45

*Lack of time prevented waiting for complete recharge of train.
†Not observed. (10 lb. reduction of Demonstration No. 1 give 25 lb. cylinder pressure on last car.)
The value of a No. 8 drill orifice is 48 cu. ft. of free air per minute from 70 lb.

SPECIAL DEMONSTRATION B (REQUESTED)
QUICK ACTION TIME ON 100-CAR TRAIN

Total Length of Brake Pipe (Less Branch Pipes and Engine and Tender)—5,837 Ft.

Time from movement of brake valve handle to piston start on Car 100, 10.7 sec.; rate of emergency propagation, 545 ft. per sec., or 372 m.p.h.

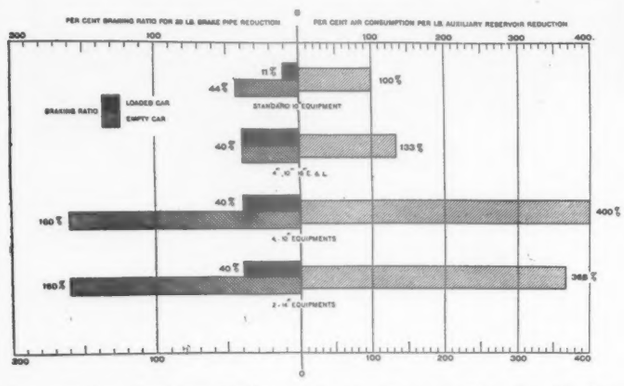
Speed and Air Consumption with 100-Car Train

The speed and brake pipe pressure as recorded on the 100-car train are reproduced herewith. Briefly the record shows the following for the descent of Kellysville and Allegheny grades:

	Length of 1½ per cent grades	Average Speed
Summit to Kellysville	10.5 miles	20.6 m. p. h.
Merrimac to Fagg	7 miles	19.0 m. p. h.

The speed down the Kellysville grade ranged from 18 to 24 m.p.h., except for a reduction to 14 m.p.h. at Oakvale. The air consumption per car was 0.328 cu. ft. of free air per minute.

The train performance down the Allegheny grade from Merrimac to Fagg was a duplicate of the run down the Kellysville grade. At no time did the speed range exceed a 5 m.p.h. variation from the desired mean speed of 20 m.p.h. The air consumption was 0.304 cu. ft. of free air per minute per car.



Comparative Braking Ratios and Air Consumption for Various Brake Equipments

Handling a Train of Empty Cars

On Thursday, May 26, a train of seventy-five empty 120-ton gondolas was hauled up the grades from Roanoke to Princeton. During this run tests were made of the empty and load brakes in order to demonstrate the practical elimination of shocks during heavy service and full emergency applications.

The train was hauled by a 2-10-10-2 Mallet to Rich Creek. A full service stop was made west of Salem (about 8 miles west of Roanoke) from a speed of 18 miles an hour in 38 seconds with a brake pipe reduction of 12 lb. A full emergency stop was made on the grade near Eggleston (about 55 miles west of Roanoke and 22.6 miles east of Rich Creek) in 18 seconds from a speed of 20 miles an hour with the brakes in the light capacity position.

Demonstration With 75-Car Train

The concluding run of the demonstration was made on May 27, from Princeton to Roanoke with a train of 75 loaded 120-ton capacity cars and the observation car. The gross weight with the locomotive was 12,519 tons; without the locomotive 12,070 tons. As on previous occasions, a brake pipe pressure of 75 lb. was maintained.

Five cars in the train (15th, 30th, 45th, 60th and 74th) had open drain cocks in the cylinders. The speed fluctuations did not exceed 5 m.p.h. for any brake cycle except on the observance of a 10 m.p.h. slow order at one point a short distance east of the summit. The average speed down the Kellysville grade was 17.6 m.p.h. and from Merrimac to Fagg 19.2 m.p.h. The air consumption was 1.12 cu. ft. of free air per minute per car on the Kellysville grade and 0.97 cu. ft. on the Allegheny grade.

Just east of Rich Creek station, on a .9 per cent descending grade, an emergency stop was made from a speed of about 27 m.p.h. As measured by rail lengths, the stop distance was 760 ft. The slack was stretched prior to the emergency brake application and the run-in was even milder than that of the preceding day's test.

Watching Recording Apparatus on Observation Car

With a view of making this test under more critical conditions, a repeat at about 13 m.p.h. was made just east of McCoy station on an ascending grade of .2 per cent. The slack run-in at the rear end came just at the stop, and while more noticeable than in the first test, was very mild, being insufficient to move a camera in a leather case acting as an improvised slidometer on a planed board bench. The stop distance according to rail lengths was 230 ft.

The train was handled between Merrimac and Fagg with the same uniform control as on Kellysville grade, including a slow down for orders at Elliott, with a total variation of speed of from 13 m.p.h. to 23 m.p.h.

The train arrived at Roanoke at 3:10 p. m., a total of 8½ hours elapsed time, showing the practicability of handling a 12,000-ton train in regular traffic in reasonably close to an eight-hour period.

Pyrometers Promote Locomotive Efficiency

The Value of Pyrometers Applied to Superheater Locomotives Has Been Proved by Many Service Tests

As a positive check on the efficiency of superheater locomotive performance, pyrometers* have demonstrated their great value. They register steam temperatures at all times, and enable engine crews to keep a constant check on the fire, water level, draft conditions and locomotive performance generally. A locomotive cannot be operated without a steam gage. Why should it operate without a temperature gage since its efficiency is dependent upon the degree of superheat attained?

To illustrate the importance of pyrometers, a hypothetical case is assumed of a locomotive operating without one and hauling a specified train load on a regular run. Suppose

Location of Pyrometer Indicator in Cab

that the locomotive operates on the first trip all right as far as steaming and fuel consumption is concerned. A front end air leak may develop on the second trip and easily pass overlooked for a day or two. Gradually the engine crew notices an excessive coal consumption, and finds difficulty in keeping up steam. As the leak becomes greater the flues get dirty, the fireman is finally unable to keep up steam pressure and the locomotive fails on the road.

When locomotives are equipped with pyrometers, however, troubles are apparent as soon as they develop, and can be corrected. Any defect which tends to decrease the gas temperature and resulting steam temperature is immediately reflected in the pyrometer. A low steam temperature warns the enginemen that something is wrong and when this is reported at the end of the trip, the roundhouse force can locate and correct the trouble before the locomotive goes on the road again.

It is important that engine crews be instructed as to the purpose of pyrometers and this instruction should require but a short time since they already know that the efficiency of a superheater locomotive depends upon the amount of superheat attained. A crew, trained to operate a locomotive equipped with a pyrometer, can check its operation and know when it is working at highest efficiency. Defects in operation, being made apparent by a low steam temperature reading, can be quickly corrected and with a little practice, avoided. The net result is a saving in fuel and more efficient locomotive operation.

*The detailed description of a pyrometer completely adapted to locomotive conditions and able to retain its accuracy under severe usage is given on page 1721 of the June 24, 1919, Railway Age.

Defects Shown by Low Pyrometer Readings

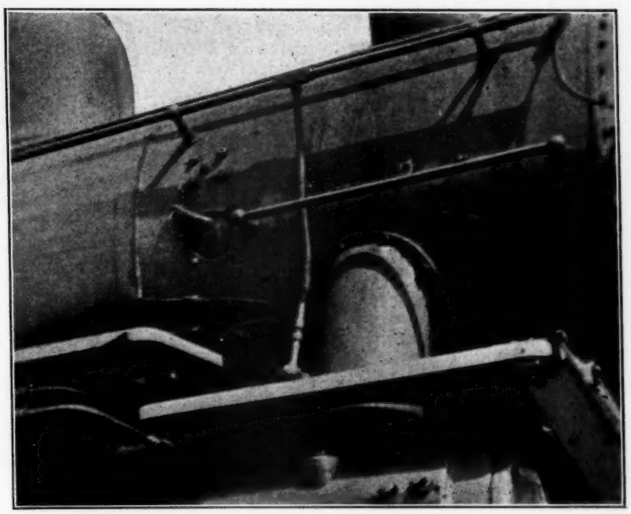
Where pyrometers are being used, many enginemen depend more completely upon their indications than upon the steam gages. When a locomotive is working under average conditions, and a perceptible drop in steam temperature is noted, some of the following defects either in the operation or the condition of the locomotive may be looked for.

First—The water level in the boiler may be too high, causing priming. The superheater then has to evaporate the water in the steam and consequently the final temperature of the steam is reduced.

Second—The fire may not be in a proper condition, due to too heavy or too light firing. Either condition will reduce the firebox temperature and consequently the final temperature of the steam.

Third—A portion, or all, of the large boiler flues may be stopped up.

Fourth—Air or steam leaks may be present in the front end, a condition which seriously affects the draft.



View Showing Steam Fixture in Steam Pipe and Connection to Cab Through Handrail

Fifth—The damper may not operate properly and interfere with the passage of gases through the flues.

Any one, or any combination of these defects will cause a reduction in steam temperature which is immediately indicated by the pyrometer.

The first two of these conditions can be prevented or corrected by the enginemen; the last three should be reported for attention at the terminal. Prompt attention to these conditions will save hundreds of thousands of dollars for the railroads, not only in fuel, but in eliminating delays and preventing minor repairs from becoming costly. Advantages resulting from the use of pyrometers would seem to warrant the general application of these instruments to all superheated locomotives.

Suggestions for Improvements in Locomotives

BY JOHN MITCHELL

The average railroad man usually has some suggestions to offer for solving any problem which may arise. Many things require more or less frequent attention due to some neglected point in design or application, or by a failure to give the necessary attention at the proper time. A more frequent mention of the every day problems of the man in the roundhouse and in the shop with a discussion of the possible changes which would tend to improve conditions, would undoubtedly assist in the solution of many such problems. With this object in view, the following suggestions, gathered from various sources, are presented for consideration.

Lubrication

This always has been, still is, and will continue to be a live issue, as the life of moving machinery is dependent to a large extent upon the proper lubrication of bearings and other surfaces in sliding contact. Hydrostatic lubricators are in general use on locomotives, but it is surprising how little attention is given to their performance. Sometime ago one of the first-class roads undertook to find out how many of their engines had the oil pipes so applied that the oil would flow from the lubricator to the steam chest without being retained in sags in the pipes. The pipes were disconnected at the lubricator and at the steam chest. One man then poured a quart of oil into the pipe at the cab end, while another man with a can of the same size caught what came out at the steam chest end. Any deficiency would indicate the amount retained in pockets or sags. As the lubricator cannot supply a uniform feed of oil unless the pipes have a continuous fall, a test, such as outlined, should be made at least every time an engine is given a general overhauling.

A leaky lubricator throttle valve is a common occurrence and every one wastes some oil whenever the filling plug is removed, as well as being a source of danger. As a rule the men who fill lubricators do not regularly report defects on engines, consequently, unless the valve leaks so badly that it is impossible to fill the lubricator, the condition is not reported and repaired. These valves should be systematically examined and repaired if necessary. In such places it is advisable to use a high-grade standard valve so that a leaky one may be replaced by another valve and the defective one repaired at convenience.

Driving Boxes

The driving boxes in common use today differ but little except in size from those used years ago. This is a good field for the practical inventor. The advantage of cutting out the brass in the crown so that the journal may not have a bearing at this point is quite generally recognized. This enables the brass to wear to a perfect bearing without becoming pivoted with consequent wear and pounding on the sides. Most roads follow the practice but do not carry the principle far enough for it is entirely possible to cut out enough of the crown of the brass to control the wear and cause it to be uniform over the entire bearing surface. No general rule can be laid down and it is necessary to experiment with different classes of engines to determine the most satisfactory width for the slot in the crown. The heavier the engine, the wider the slot should be made. On some heavy power the width is three inches or more. The proper size having been determined by tests, brasses can then be cast with the slot cored in.

Reversing Gears

Modern heavy locomotives made necessary the adoption of the power reverse mechanism, but it has also proved to be an economical addition to lighter engines, particularly those in switching service. It is positive in action, invaluable in an emergency, a good all-around safety device and as it saves the time and strength of the engineman, offers greater assurance that he will use the proper cut-off by hooking up the engine when it should be done.

Power reverse gears have their faults, of course, among them being the tendency to creep unless properly maintained, the tendency to freeze, the necessity of a steam, as well as an air connection, and the absence of flexibility in not being subject to manual operation. A screw reverse operated by a small air motor would overcome these weaknesses, permit of closer adjustments of cut-off, obviate the necessity of a steam connection, do away with creeping, simplify the mechanism and be a real safety device as it could be operated instantly by hand under any condition. It is strange that such a mechanism has not been developed.

Cylinder Cocks

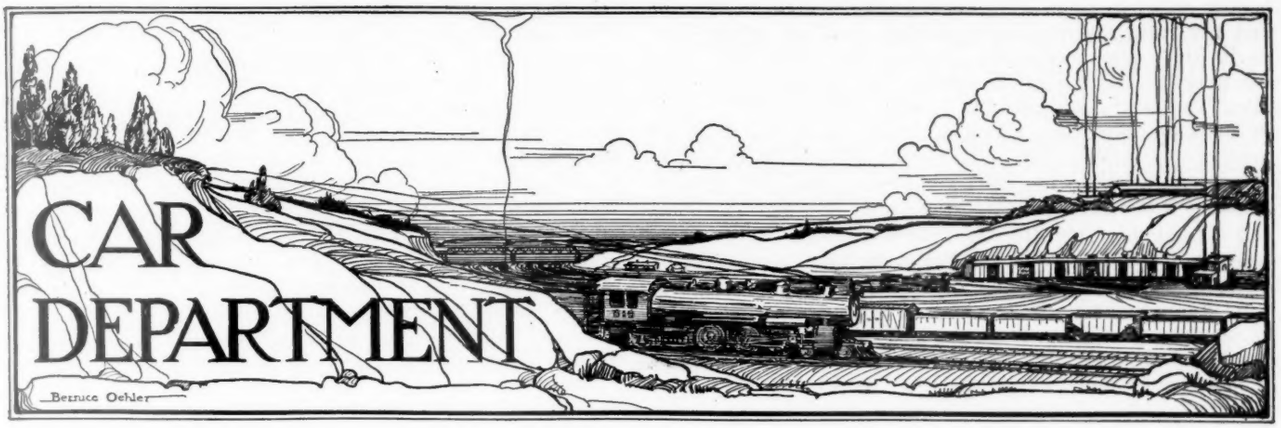
Condensed water is removed from the cylinders by a simple device to which but little attention is given although considerable money is lost due to the neglect of maintenance. Cylinder cocks with a discharge opening not over ½ in. in diameter are still used, despite the fact that such an opening is entirely inadequate to discharge the water from an 18 in. or larger cylinder. These cocks should have sufficient opening to discharge all the water in one revolution, provided the engine is moved off slowly. This would require the use of an opening of about 2 in. diameter, and would probably necessitate the development of a gate or quick opening valve. Cylinder heads are often knocked out, cylinders cracked or broken, piston packing broken, lubrication destroyed, rod packing cut and steam leaks either started or aggravated, largely due to the use of cylinder cocks of inadequate capacity for large engines.

The operating mechanism of cylinder cocks is commonly neglected as the importance of its maintenance is not properly emphasized. This is particularly true of the air operated mechanism used on Mallet locomotives where the four air cylinders are located underneath the bottom guides, in which position the vibration of the guides and the close proximity to the ground frequently make them inoperative. As simple a device as the cylinder cock rigging should be so designed that it would require repairs only at infrequent intervals. Any device which requires repairs practically every trip will inevitably be badly neglected.

To overcome the conditions referred to on Mallet locomotives, one road has developed an arrangement which consists of only two cylinders made of 3 in. pipe, these cylinders being located midway between the frames on a suitable brace, one for the high pressure cylinder and one for the low pressure. The power from the air cylinders is transmitted to the cylinder cock slides through a substantial shaft, to each end of which is attached a lever so fulcrumed as to give the desired power to move the slides. The mechanism is simple, positive and reliable and the location of these air cylinders is such that they are not subject to fouling and can be so securely fastened as not to work loose. They consequently require but little attention.

A semi-automatic air operated cylinder cock has proved effective on engines other than Mallets. The cock is normally held open by a coiled spring until closed by admission of air to the operating cylinders. The spring is attached to the back end of the cylinder cock slide and held in compression between a lug at the end of the slide and the cylinder cock, thus forcing the slide back and opening the cock.

It is a difficult matter to impress upon shop forces the necessity of using an extra effort to maintain a device which is considered to be of a poor design and while such an attitude may not be justifiable, it is natural and can best be overcome by the installation of an improved device. It will well repay any road to go over cylinder cock riggings with these suggestions in mind and improve them.



Draft Gear Tests of the Railroad Administration

Car-Impact Tests or Symington Test Plant Methods of Combining and Interpreting Records

IN order to obtain an exact knowledge of the action of gears in service, car-impact tests were made, using the same gears as in the foregoing laboratory tests. The results are therefore of special interest as showing not only the action of the gears themselves under service conditions, but as demonstrating also, for the first time, how laboratory tests compare with service action. The gravity testing plant of the T. H. Symington Company at Rochester, N. Y., was used for these tests. In general, the use of private laboratories of interested companies was avoided, the preference being given to the testing facilities of railroads. This being the only plant of its kind in existence, however, and the Symington Company being interested in the manufacture of draft gear attachments rather than of gears, and having no gear in the tests, the Section availed itself of the opportunity to use the Symington testing facilities.

This plant was originally built for investigating the action of full-sized cars, either loaded or empty, when equipped with different draft gears. The Symington Company, who were practically pioneers in this work, constructed the plant with the prime idea of studying the action of the cars when equipped with different gears rather than investigating the action of the gear itself. As originally constructed and used, much valuable information was obtainable from this equipment although, as in any other impact testing, misleading conclusions as to the relative merits of draft gears could be unintentionally reached by subjecting gears to over-solid car velocities. The extended remarks heretofore made regarding over-solid laboratory testing apply equally as well to this service testing. Over-solid testing should never be done except for discovering weak gear construction. Some of the earlier tests have been of value, however, in showing what slightly over-solid speeds are necessary to produce gear injury and failure. After the owners had made certain changes and additions desired by the Section for a more exact investigation of both gear action and car action, at speeds within the ranges of the gears, the Symington plant was taken over and operated by the United States Railroad Administration for the purpose of the car-impact tests.

The Symington Test Plant

The testing plant of the T. H. Symington Company, the instruments used and the records obtained were described in the *Railway Mechanical Engineer* for May, 1919, page 249.

In general this test plant consists of a test track with two full-sized cars which can be caused to collide at any desired velocity, accurate means being provided to record the results. The first portion of the track is inclined in order to impart velocity to one of the cars. An electric winch is located in a small house at the top of the incline and this winch through the medium of a puller car, is capable of drawing a loaded 50-ton car up the incline. At the foot of the incline is a section of approximately level track which terminates in a section of track on an ascending grade. The track is straight throughout its length.

Two composite gondola cars of 50 tons capacity are used, one of which, termed for reference car "B," is spotted at a certain point at the beginning of the 1 per cent grade. The other car, termed car "A," is drawn up the incline by means of the puller car and winch. A movable trip block is clamped on a third rail located alongside the track. The puller car has a projecting trip-lever which strikes the trip block, releasing car "A" and allowing it to roll down the incline. When fully on the level portion of the track, car "A" collides with the standing car "B." Either or both cars may be equipped with draft gears of any type, and both cars are free to follow such movement during and after the draft gear cycle as may result from the use of the particular gear.

The test cars are 50-ton low side, composite gondolas, 46 ft. 0 in. inside length with fish-belly center and side sills and with a steel frame superstructure. The cars have 2¼ in. floor planking and 3¼ in. side and end planking. Each of the cars has four diagonal floor braces of 5 in. channels at the corners, and each has been supplied in addition with four diagonal braces at the center, extending from the side sills to the center sill. The light weight of each car is 47,800 lb., and they have been loaded with pig iron to give a total gross load of 143,000 lb. per car. Wood cribbing is arranged inside of the car to hold the lading against shifting. The brakes were removed from the cars to avoid any possibility of dragging shoes.

The test cars are equipped with Farlow Two-Key draft gear attachments and the test gears may thus be carefully adjusted in the draft gear pocket. In this arrangement the gear is positioned between the arms of the horizontal wrought steel yoke. In buffing, the gear seats against the rear follower, which latter bears against the rear of the yoke. The yoke in turn seats against the cast steel back-stop and

bolster center casting. This casting bridges between the sills and ties them together, there being a total of seventy-four ¾ in. rivets supplied for transferring the buffing force from the backstop casting to the center sills in each of the test cars. The draft gear is held to compressed position by means of the second draft key, which in service forms also the front pulling stop for the gear. The regular practice in this form of attachment is to have this key protect the draft gear by allowing it to strike the ends of the slots in the check plates and sills at the same time the gear goes solid. In the tests, however, the slots were lengthened at the rear to prevent this key ever going solid.

A dummy coupler having a flat buffing face and of 16 sq. in. cross sectional area, was used instead of a standard coupler. The front key, which passes through the key slot of this coupler and through the front slots in the yoke, was used in these tests for supporting and aligning the parts only. The front end of the dummy coupler shank was guided both vertically and laterally. In all tests care was taken to see that the draft gears seated against the second key and not against the coupler key. The artificial looseness or slack resulting between the coupler butt and the front follower was taken up by temporary wedges before each run so that all action, both on compression and release, could be restricted to the gears themselves and be definitely measured and recorded.

Action of Cars During Impact

In any case of car-impact, the first and prime effort is for the velocities of the two cars to equalize; that is, for car A to slow down and car B to speed up. This is caused by the effort of car A to push car B ahead, which continues as long as the velocity of car A is greater than that of car B. This pushing or propelling effort must always result in the compression or yield of some part or parts of the car. The draft gears are supplied for the purpose of providing this yield and to reduce the amount of yield required from the car structure.

But in every case of impact, some part or parts of the cars, either draft gears or other more rigid car parts, will continue to compress or yield until the very instant when the velocities are equal. For light impacts, the velocities are usually equalized without compressing the draft gears to their full amount. In the case of an over-solid velocity, the draft gears will first be fully compressed, their resistance slowing down car A and speeding up car B. But in this over-solid case, when the gears are fully compressed, car A has still a greater velocity than car B and it will be apparent that car A will continue to urge car B forward. This results in an impact directly upon the gear housing.

The additional work to be done must be accomplished by certain forces working through a certain space represented by the additional yield of the solid parts, the force going directly through the housing to the sills. The couplers, gear housing, and sills must now continue to yield until the car velocities are finally equalized. The amount of yield and the magnitude of the forces are inversely proportional and depend entirely upon the sturdiness of, or the resistance offered by, the parts. The sturdier the parts, the more force will be required to deform them and the less will be the amount of penetration and yield and incidentally the lower will be the unit stress. On the other hand, the lighter the parts the greater will be the yield and the less the force, but the higher will be the unit stresses. Accordingly, although providing a temporary cushioning for the over-solid blow, the lighter parts will shortly be deformed or broken. Any weak link, be it coupler shank, draft gear housing, draft lugs or center sills, will reduce the force peak but only at the expense of its life.

The velocity of car A is thus being gradually decreased and that of car B increased until the velocities are equal, at which instant all parts have reached the maximum of compression. If all of the parts were perfectly inelastic, if in other words, there should be no tendency for the gears to release themselves or for the car structures to give back the energy of their elastic yield, it is evident that there would then be no force of recoil to separate the cars, and both cars would accordingly move off together at this equal velocity. With equal rolling and grade resistance, the cars would continue together until both finally came to rest without separation. Except for the slight loss due to rolling resistance, the work done in compressing the gears and car structure is thus always equal to one-half of the original kinetic energy in car A, and it should be especially noted that this is the same whether there be no recoil of the gears and car parts, or full recoil.

The force exerted between the cars in compressing the gears and car structure is entirely independent of the question of absorption. Up to the point of maximum compression the matter of absorption of energy has not entered into or influenced the problem. It is entirely a question of force and yield and it should be remembered that frictional resistance, while truly absorbing energy (foot-pounds) does not in any manner whatsoever reduce or "absorb" force. The force required to close a friction draft gear, and consequently the force going through the gear to the sills, may be greater or less than a spring draft gear of equal capacity, depending solely upon its compression curve, and not in the slightest degree upon its percentage of absorption. The cushioning value of a gear therefore is not measured by absence of recoil, or energy absorption, but solely by its action during the closing period. Whether or not a gear has extensive recoil has nothing to do with its action on compression, or with the force delivered by the gear to the car during its compression.

In practice, the cars having reached a point in the draft gear cycle where their velocities are equal, and the compression period of the cycle completed, the release of the gears begins. All gears have more or less recoil and it is this force, together with the rebound of the car structure, that tends to part the cars and to cause one car to travel faster and farther than the other. It should be especially noted that the force of recoil has the same effect between the cars as the force of compression; namely, to reduce the velocity of car A and to increase the velocity of car B. During the period of gear compression the force between the cars, or the force tending to accelerate car B, results from the higher velocity of car A, or its direct tendency to push car B ahead. During the period of draft gear release, the force tending to further accelerate car B or to urge it forward, results from the recoil or return of stored energy in the two draft gears and both car structures.

The recoil of the gears and car parts thus giving to car B a greater velocity and to car A a lesser velocity, car B will begin to travel faster than car A, and the gears, following the resulting parting of the cars, will continue to release until final separation of the cars. It is evident that the greater the force of recoil, or release, the greater the pressure between the cars during release, and consequently the higher will be the velocity attained by car B and the greater the retardation of car A. A gear with 100 per cent recoil would actually bring car A to rest by the time the cars separate, while car B would be pushed ahead at a velocity practically equal to the original impact velocity of car A. On the other hand, a gear with no recoil, or 100 per cent absorption, would, as heretofore set forth, cause both cars to move off together, each at one-half the initial velocity of car A.

Gear absorption is thus inversely proportional to the pressure exerted between the cars during the period of release, the effect of high absorption being to hold the two cars at nearly equal velocities after impact. This means, in effect, that with high absorption of energy, car B will not be pro-

pelled at so high a velocity and consequently will strike the next succeeding car at a reduced velocity, while with no absorption, car B will strike the next car at almost the same velocity as the original of car A. Absorption therefore is not primarily a means of reducing the force of impact between the first two cars, or of protecting these cars, but is a means of reducing the magnitude of the successive impacts between successive cars in a train.

The following may be accepted as general principles of draft gear action in impact:

1. That draft gears are compressed only because of differences of velocity between adjacent cars.
2. That the resistance offered by the gear during compression tends to overcome the difference of velocity of the cars and tends to bring both cars to the same velocity.
3. That gears continue to close, and at over-solid velocities the car structures continue to compress, until the car velocities are equalized.
4. That this action of a gear is independent of its ability to absorb energy, or in other words, is the same whether the resistance be obtained from friction or from spring action.
5. That the cushioning offered by the compression of a draft gear is not dependent upon its percentage of absorption.
6. That absorption does not in any manner reduce the force going through the draft gear to the car sills while the gear is being compressed, and does not lower the force exerted between the first two cars colliding. That it does act to lower the velocity with which the second car strikes the third car and consequently reduces the force between successive cars.
7. That the amount of "work-absorbed" by a gear, or the percentage of absorption does not regulate or reduce the force of first collision, but is important as determining whether shocks will run practically undiminished throughout the train or whether there will be successive reductions in their magnitude from car to car.
8. That the first measure of a draft gear is the amount of energy required to close the gear, this being the sole factor from which to determine for what switching speeds a gear is suitable. This is expressed as "work-done" and has no relation whatsoever to "work-absorbed."
9. That the next requirement is that a gear, either spring or friction, shall compress with such a rate of increase of resistance as will cause the lowest practical ultimate force and the least practical vibration of the car structure.
10. That the next measure is with respect to the action of the gear on release or the amount of the recoil, whether the energy of compression is returned, to go on to the next car, or whether it is partially absorbed as by friction. This property is expressed by the term "work-absorbed."

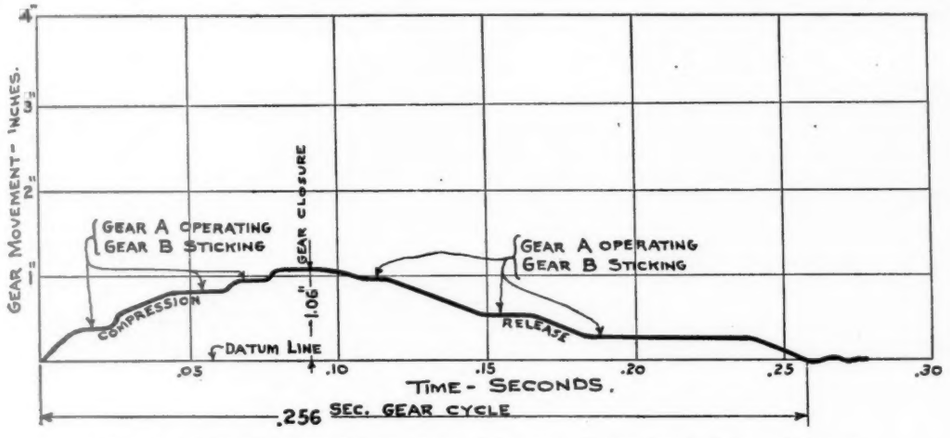


Fig. 4—A Typical Time-Closure Curve Produced on the Small Drum of Car B

Records in Car-Impact Tests

In the car-impact tests the following records were taken: impact velocity of car A; travel of cars along track; draft gear travel and action; seismograph readings and graphs of car action.

From these prime records a complete study of the action of both the gears and cars can be made, the details of which will appear as the manner of making and interpreting the several records is discussed.

Impact Velocity

The first information needed in such tests is an accurate knowledge of the velocity of car A at the very instant of impact. In these tests car A was caused to draw a velocity line upon a revolving drum, so that the exact velocity at the very instant of impact is obtained within a possible error of less than 1 per cent.

Travel of Cars Along Track

An interesting point in connection with this record is that for equal impact velocities, the higher the recoil of the gear used, the greater the distance car B will travel. In general, the recoil of gears will be proportional to the distance between the cars after coming to rest; that is, the greater the recoil the farther apart will be the cars when they have finally come to rest.

Draft Gear Travel and Action

Knowing the impact velocity, the next point of interest is the amount of and the nature of the travel or yield of the draft gears. The test cars are equipped with friction plunger gages to show the amount of coupler travel. This corresponds reasonably closely with the actual draft gear travel, but is not sufficiently accurate for analytical investigations.

In order to obtain a more direct knowledge of the movement and action of the gears, car B is provided with a small revolving drum upon which is drawn a curve which shows not only the amount of draft gear movement for that car but the character of the movement; that is, whether the gear compresses and releases regularly or irregularly. A case is secured to the side sill of car B in which is a small motor-driven drum which extends transversely of the car. A pencil is caused to move lengthwise of the drum in harmony with the movement of the front draft gear follower. The drum is covered with paper, and as the gear is compressed or released the pencil is moved a corresponding distance along the axis of the revolving drum, and thus produces a time-closure diagram for the gear in car B.

Tests were in each instance made with gears in both cars and again with a gear in car B only, car A in the latter case being fitted up with a solid steel block instead of a draft gear. The action of the individual gear can be best studied under these latter conditions because it is definitely known that any irregularities recorded are due to the particular gear. In the former case the record does not determine which of the two opposing gears is responsible for the irregularities. Such irregular action is almost invariably recorded when both cars are equipped with gears. The specimen card reproduced in Fig. 4 was made from the gear in car B when each car was equipped with a friction draft gear. This card

shows the typical action of friction gears in the double-gear tests, or when both cars are equipped with gears.

By means of these cards it is found that while some draft gears act smoothly and regularly, others, particularly those from friction gears of high capacity, are often closed by a succession of alternating movements or jerks. This will be shown as the individual cards are reproduced. The lower capacity gears naturally show smoother gear action than those of higher capacity. The cards show that with a gear in each car, the two gears do not work in harmony; that frequently on compression, and almost invariably on the release, one gear will work for a while and then the other one will operate. From this it is concluded that twin arrangement of friction draft gears is not permissible.

Seismograph Readings

Each of the test cars is equipped with a pendulum device, secured to the side of the car, and so arranged that the accurate record of the performance of both cars during the brief period of the draft cycle. A recording apparatus, arranged to draw simultaneous time-displacement curves of both cars, was designed and installed and a system of certain reference lines worked out whereby these curves could be later so super-imposed that at any instant during the draft gear cycle an exact knowledge of the performance of both cars could be had. These curves are commonly referred to as "car-movement curves." A photograph of the instruments for producing these curves is shown in Fig. 5. The apparatus has two drums mounted upon a common shaft and is placed on a stand alongside of the track. The drums are so mounted upon the shaft that one drum is alongside of the striking end of car A and the other alongside of the struck end of car B. Each drum has a pencil carriage that is moved lengthwise of the drum by the movement of the car, each car having a pencil-propelling plunger attached to its side sill. Suitable angle iron guides are arranged upon the instrument stand

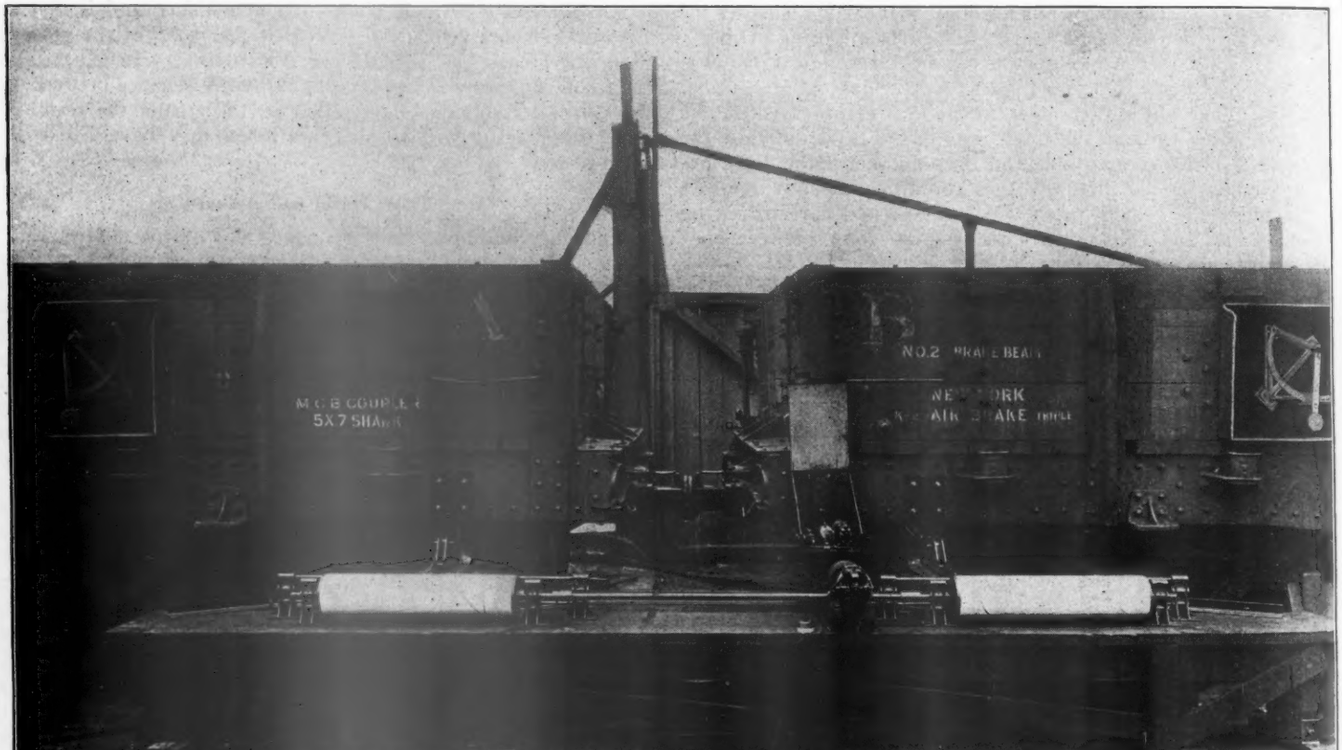


Fig. 5—Instrument for Recording Car Action

retardation or acceleration of the cars will cause the pendulums to swing upward by virtue of the inertia of their own masses. Graduated quadrants are arranged as guides for the pendulum weights, and a light friction runner is carried with the weight and is left standing upon the guide at the highest point reached by the pendulum. The seismograph records are usually attractive to the observer but are not of great importance in the study of gears.

Graphs of Car Action

As the final study of draft gear action must lie in a study of the results of the use of the gear upon the car and its lading, arrangements were made to obtain a complete and to cause the plungers to move into or out of engagement with the pencil carriages at the proper times.

Making a Test Run

Car B is spotted, always at the same definite station along the track. Car A is also spotted, the buffing faces of the couplers being just in contact and all loose slack being eliminated or compensated for. With the cars so spotted and with the A and B pencils in positions on their respective drums corresponding with the positions of cars A and B respectively, the drums are rotated a few times, thereby drawing the datum lines, (see Fig. 6). At the same time the small drum is rotated a few times so that its pencil draws

the datum lines for this record. It will thus be seen that all of the datum lines are drawn with the cars and gears in position as at the first instant of impact; or, in other words, at the beginning of a true gear compression. Accordingly, in comparing the cards, it is definitely known that all car movements and gear action can be compared from these common datum lines.

Without rotating the drums, each of the pencils is given a slight longitudinal movement, in order to draw the reference lines. The pencil for car B is left standing exactly upon the datum line. Car A is then drawn away from car B and the pencil for car A is drawn along the axis of drum A in order that the approaching car A may propel this pencil for some distance before the pencil reaches the datum line, or the position where the two cars first meet.

By means of the datum and reference lines on these two cards a system of super-imposition of the two curves has been developed and in Fig. 6 these curves have been so superimposed. This is done by matching up both the datum and reference lines and tracing one curve upon the other. The exact meeting point of the cars is thus established for both curves and both are also synchronized as to time. Consequently both the velocity of the cars and their relative positions can be determined for any instant. And at any instant, also, the distance either car has moved from its spotted positions is known.

It will be seen that car A, during the first portion of the draft gear cycle continued to travel at a higher velocity than car B. As car A thus encroaches upon car B the draft gears are compressed, the distance between the two super-imposed curves representing draft gear compression, together with the slight yield of the car bodies. Car A continued to run down upon car B, its velocity gradually decreasing and the velocity of car B gradually increasing due to the draft gear forces exerted between the cars, until both cars were of equal velocity. This point corresponds with the point of maximum draft gear compression and can be readily determined by finding the maximum ordinate between the two curves.

From this point on, the velocity of car B becomes greater than that of car A due to the forces of draft gear recoil between the cars. Consequently, car B moves away from car A, allowing the draft gears to continue their release. At the point where the two curves cross there is no relative displacement of the two cars, or in other words, each car has travelled the same distance from its datum line, and it is therefore definitely known that at this instant the cars parted and that the draft gear cycle was completed.

From the superimposed curves, Fig. 6, it is possible to obtain a wide range of information concerning car action and draft gear action. The dotted line erected upon the datum line, for example, shows the movement of the two draft gears during compression and release. This curve is obtained by the simple process of stepping off the ordinates between the two curves upon the datum line as a base. The point where this draft gear curve reaches its maximum height is the point of maximum draft gear compression, and a vertical line has been drawn to indicate this point on the curves. From this it is then seen that the period of draft gear compression was 0.090 seconds and the period of release 0.166 seconds, the entire draft gear cycle, or the total length of time the cars were in contact being 0.256 seconds.

At the instant of maximum draft gear compression, car A had moved 2.52 in. along the track from the point of impact, while car B had moved but 0.42 in., car A thus having encroached upon car B for 2.10 in., causing a corresponding amount of gear closure. At this instant, car A ceased encroaching upon car B, as shown by the falling off in gear closure. At the instant of maximum gear closure the velocities of the cars were equal, and the lines established tangential to the car-movement curves at this point denote the common velocity at this instant. These tangential lines also indicate the paths of the car-movement curves had there been no force of recoil, or if the draft gears had stuck. Angles have been drawn in to indicate the influence of gear compression and gear release, and the dimension of 4.25 in. shows the track movement of the cars during the entire draft gear cycle.

The card of Fig. 4 was drawn by the action of the draft gear in car B during this same run. It will be seen that this

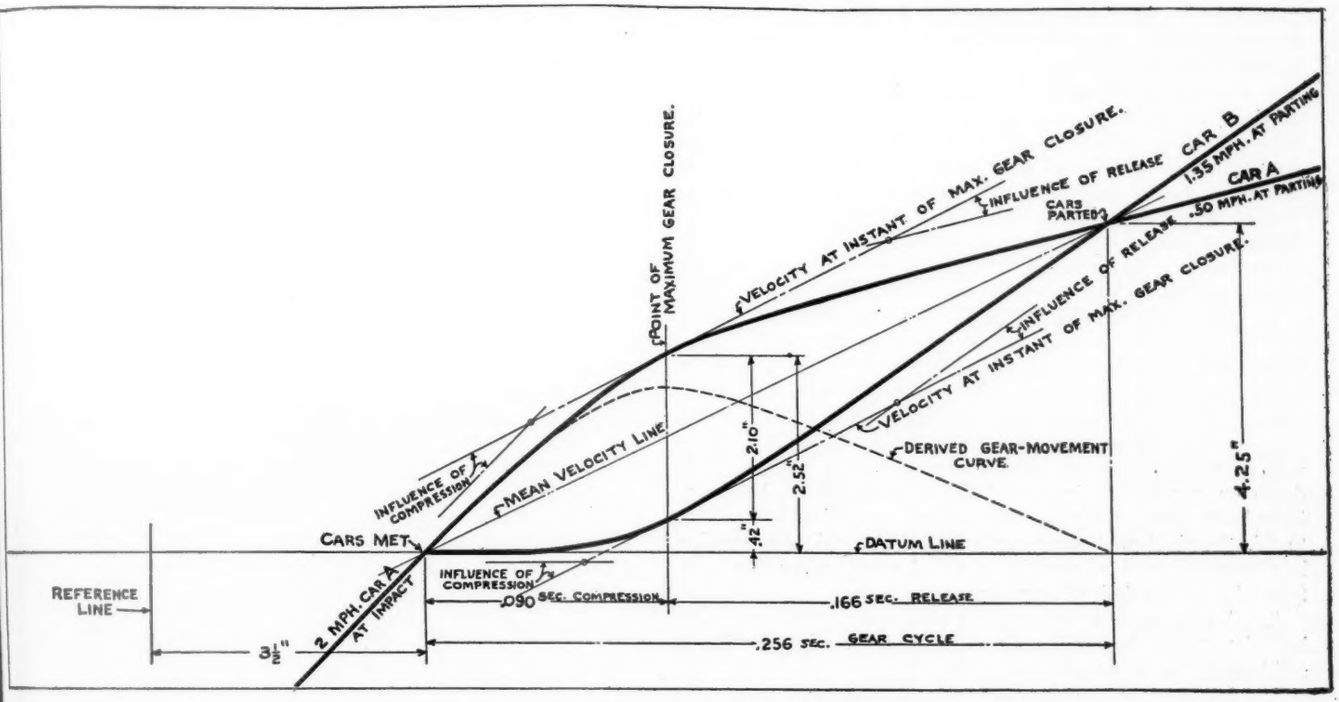


Fig. 6—Specimen Car-Movement Cards from Drums A and B Superimposed

gear closed 1.06 in., thus showing that the gear in car A closed 1.04 in. While the line in Fig. 6, representing the sum of the actions of the two gears is smooth and regular, yet the individual gears did not operate so regularly. The compression and release was attained by first one gear operating and then the other. This is to be expected from friction gears and indicates variations in the effective co-efficient of friction. No special demerit is attached to this action of a friction gear, as either one gear or the other is operating at all times.

From the superimposed curves it is a simple matter to determine the exact impact velocity of car A and also the exact velocities of both cars at the instant of parting. It is also possible to determine by tangents the change in velocity of each car during any period of draft gear compression or release. It is further possible to plot curves showing the instantaneous velocity of both cars, and from these it is a matter of simple calculation to produce curves showing the instantaneous energies in the two cars. From the rate of change of velocity, the mean or average forces working between the two cars throughout the period of impact may be computed and a continuous time-force curve plotted.

By stepping off and plotting the vertical distances between the superimposed car-movement curves as heretofore explained, a time-closure curve of draft gear action can be produced. This curve will show the complete draft gear action, both compression and release, plotted against time, and in cases where a gear is used in car B only, the curve will practically coincide with the curve drawn by the small drum on car B. This erected time-closure curve, however, includes not only the yield of the draft gears but has added to this the yield of the two car bodies. The uniform practice has been followed of working up and reproducing for each type of gear the following runs:

1. A run, made at or near the closing point, with a calibrated test gear in car B only, car A being equipped with a solid steel block instead of a draft gear.
2. A run made at approximately one mile per hour, each car being equipped with a calibrated test gear.
3. A run made at or near the closing point, each car being equipped with a calibrated test gear.

The first of these is worked up primarily that the action of a single calibrated gear in the car-impact tests may be compared with the action of the same gear in all of the laboratory tests, the possible influence of a second gear being removed The second is worked up that a complete knowledge may be had of the action of each type of gear at low impact speeds. These low speed runs are especially useful in a study of train starting. The third is worked up as showing the best that may be expected from each type of gear at the maximum impact speed it is capable of cushioning, and gives the true comparison of the gears from the standpoint of yard service.

The same gears of a type were used throughout the test, the general practice being to first make tests with both cars equipped, and then after replacing the gear in car A with the solid block, to make the single gear tests.

Means of Preventing Hot Boxes

An interesting discussion on the subject of hot boxes, their cause and the steps to be taken to minimize their occurrence, took place at a recent meeting of the Indianapolis Interchange Car Inspection Association. Some of the factors involved were so well stated by J. C. Stewart, foreman freight car inspectors, Cincinnati, Indianapolis & Western, that the substance of his remarks will doubtless be of interest to others than those who attended this meeting.

The subject of hot boxes is an old one, but nevertheless it is ever of interest on account of its vital bearing on the economical and prompt movement of traffic. Most roads have issued sufficient instructions and blue prints covering the proper methods to be followed in the application and care of packing, but this has not insured proper attention being given to the work. What is needed is a better understanding of the reasons why the recommended practices should be followed. This knowledge can be imparted best to those who have to do the work of inspection and maintenance by holding meetings for instruction, discussion and examination. Moreover, such meetings, if properly conducted, are invariably of benefit in that they induce employees to study, comprehend, think, analyze and reason out the why, how and wherefore of the work on which they are engaged.

The various causes of hot boxes may be classed under two general heads: namely, excessive bearing pressure and defective lubrication. In enumerating the different causes, they can be considered most conveniently by taking up each of these groups separately.

The causes of excessive bearing pressure most frequently met are: journal too small, load in excess of what has been found to be good practice; bearings out of alinement, or truck sides out of square with the axles (all unequally worn brasses removed are evidences of this condition); brass, box and wedge not fitting accurately, due to some improper dimension; wedge bearing unevenly on the brass; bearing warped; bearing or journal rough; bearing raised off the journal by some foreign material, often a short strand of waste; bearing tight on sides or ends; bearing too loose on sides; improper material in brass or lining, possibly too hard to fit readily the journal irregularities; brass cracked or broken, usually caused by being worn too thin before removal; second-hand brass applied; brass with loose lining or lining worn off (on account of the low grade of many of the brasses now used it is safer to depend on the lining for securing even bearing pressure).

Defective lubrication may be due to the use of a poor lubricant, or to not enough oil reaching the journal. Insufficient lubrication may result from any one of the following causes: waste not up against the journal, an insufficient amount in the box; waste lacking in resiliency; waste charred or coated with sand or grit; oil washed out of the box by water or melting snow; oil thick or sticky, oil should flow freely; poor waste, it should have good fibres to carry up the oil by capillary attraction from the bottom of the box to the journal; entrance of foreign material, such as dirt, sand and grit due to missing or defective journal box lids or dust guards; journal boxes with chill cracks, blow holes, broken or defective parts so that the boxes are not closed tightly, oil thus being permitted to leak out and dirt or water to come in; waste not properly prepared; box not properly packed or not re-packed when it should be.

Blue prints showing the proper method of packing boxes are furnished on most roads. Employees should read them carefully and be sure they understand fully the reason for everything.

The majority of the hot box troubles are due directly to improper packing or lack of attention to the packing and can therefore be practically eliminated by proper attention on the part of inspectors. Boxes should not be overpacked by crowding in the packing too tightly which results in waste grabs and prevents a sufficient supply of oil to the journal. Care should be taken to pack properly the extreme back of the box with twisted waste wrung moderately dry, to have the packing put in firmly under the journal with loosely formed packing at the sides, but not above the center line of the axle. When examining boxes and journals care should be taken to ascertain if the packing has shifted from the back to the front of the box, thus leaving an empty space at the back and that part of the journal unlubricated. Pouring oil in the box when the waste has become glazed gives only temporary relief. When packing is found to be glazed on top it should always be thoroughly stirred and adjusted or the box repacked. A failure to repack at the proper time

frequently results in a hot box. When there are indications of heating a thorough examination should be made even though from outward appearances all parts are apparently in good condition. It is better not to take chances by passing up an incipient yet bad invisible defect, but endeavor to locate it before serious trouble results.

Packing should be prepared in a tank or leak proof container to insure proper saturation and completely submerged in oil for at least 48 hours. The general practice is then to drain the packing until one pound of waste holds about four pints of oil, when it is ready for use. This work should be performed in a room which can be kept at a temperature of about 70 deg. during cold weather. The use of packing improperly prepared or renovated is simply inviting trouble.

Referring again to the subject of brasses, in order to be safe at all times they should be considered as worn out, missing or defective, when the lining is worn out. The fact that a brass has not run hot before arriving at a terminal does not guarantee that it can run to the next terminal. It should be replaced in time without waiting until it runs hot. Delay may cause needless trouble and expense.

While it is impossible to compute with any degree of accuracy the total cost of one hot box, considering injuries to journals, destruction of waste, oil and brasses and cost of labor together with the loss of revenue caused by delays, the expense is certainly larger than one would expect. A renewed effort on the part of inspectors can greatly improve the condition now prevailing in most places.

Modifications in Rules Proposed by C. I. C. I. & C. F. A.

Prices for Labor and Material; Settlement for Damaged or Destroyed Cars; Passenger Car Rules

THE A.R.A. Code of Interchange Rules was discussed at a meeting of the Executive Committee of the Chief Interchange Car Inspectors' and Car Foremen's Association held on March 3 and 4. Part of the discussion and recommendations were given in the April, May and June issues of the *Railway Mechanical Engineer*. The remainder is given below.

Rule 107 *(Continued)*

M. E. Fitzgerald: Referring to page 123, Items 25 and 25A in connection with body bolster, Item 25 refers to body bolster with top flange, R. and R. and allows 12.4 hours time which includes the R. and R. of draft timbers. Item 25A gives labor charge of seven hours and five-tenths for body bolster without top flange. Many cars are equipped with steel arms with bolsters having a top flange which do not require the R. and R. of arms, and roads are charging the 12.4 hours. As the rule reads, they are permitted to do so for any body bolster equipped with top flange. I move that incorporated in Rule 107, Item 25A, should be a reference to cars so constructed, that a labor charge of only 7.5 hours should be allowed, where not necessary to R. and R. arms.

The motion was seconded and carried.

Mr. Jameson: Rule 107, Item 123 reads: "Coupler yoke bolts, renewed, one or two, at same end of car (coupler not R. & R.)" and allows one hour for ordinary car or refrigerator car. What is the proper labor charge for the renewal of coupler yoke bolts at the same end when it is necessary to R. and R. a riveted yoke coupler, it being understood that our defect card is attached to the car for yoke bolts in place of rivets. I move that Item 123 be changed to read, "Coupler yoke bolts renewed, one or two, at the same end of car when coupler is not R. and R., one hour; when coupler is R. and R., on a bolt basis."

The motion was seconded.

F. H. Hanson: Does that refer to where you make emergency repairs in the yard? Like all roads, we find one coupler yoke rivet broken or missing and then apply the bolt. I do not know where we can R. and R. the coupler when we are applying bolts. We are applying rivets in those cases.

Mr. Jameson: The points where I know bolts are applied are where there are no blacksmiths. We ship them as many couplers as is consistent, with the standard yokes for our own equipment, but it frequently happens that a coupler is broken and it is a yoke different from any size they have riveted on; therefore, it is necessary at this outside point to drop that attachment, cut off the rivets and put in bolts instead.

M. E. Fitzgerald: If at a point like that you drop the coupler and put in the bolts, this rule allows you only the hour and does not provide for the R. and R. of the coupler. If you apply your defect card, it goes home to the owner. He will bill you the labor charge allowed for R. and R. coupler and application of rivets. You have served his purpose, moved his car, and I feel that you should have the R. and R. labor charge where that is necessary.

The motion was carried.

Mr. Jameson: I am asked very frequently, "What labor charge shall I use for packing sills?" Under the rules I have so far been unable to find them, that is, the solid timber used on a great many of our gondola cars, between the center sills.

M. E. Fitzgerald: You would be entitled merely to material charge, but no labor charge. The labor charge for sills or splicing is so made as to include the variation between the different types of equipment.

M. E. Fitzgerald: Item 296 specifies various appliances and attachments to cars that are included with the R. and R. of side plate. I see no mention made of labor charge for the R. and R. of doors or door tracks which are essential in the majority of equipment. I move that the R. and R. of door and door tracks be specified.

The motion was seconded.

A. S. Sternberg: The first rule in 107 covers that.

M. E. Fitzgerald: The rule specifies what is included. Roads are following that and billing us for the door and door track and claiming that it is not so specified. I merely want to specify it in there by adding the words, "Door or door fixtures attached to."

M. E. Fitzgerald: May I again state that the rule is so written that it includes various items. If the preceding item would cover roofing fascia, etc., why refer to it? Everybody knows it is there.

Mr. Owen: I believe that that door track was left off purposely. There is overlapping labor on that plate. Your corner bands, fascia and everything goes in with it. When it comes to the side door, side tracks or door fixtures, that is an extra charge. It should stand as it is, as an extra charge.

M. E. Fitzgerald: That is why I bring the question up. Mr. Sternberg says it is included and quotes the "unless otherwise specified" references. Mr. Owen says it is not because it is not referred to. You could not take technical exceptions to everything or you would be tied up in the bill-

ing department. These should be so written that the billing clerks will understand that this is included, as I think it is intended it should be.

The motion was carried.

Mr. Jameson: Rule 101, Item 101: "Altering height of one end of car shimming springs, net (this includes renewing of shims), $2.85." Rule 107, Item 420: "Wheels, cast iron or cast steel, R. and R., or R., including jacking car, pressing wheels, off and on, boring wheels, all necessary machine shop labor on new or second-hand axles." Will any reduction be made when altering the height of the car and applying wheels at the same time on the same end of the car? Only Item 420 specifies jacking. Does Item 101, Rule 101, include jacking? If there is no reduction, then you have a right to charge for jacking of the car with Item 101. If each of the items includes jacking of the car, then there ought to be a reduction when the two are done at the same time.

M. E. Fitzgerald: There is a confliction there. However, the matter is now before the American Railway Association and the matter of jacking is being taken care of.

J. P. Carney (M. C.): I move that this Association recommend to the arbitration committee to raise the percentage on the labor and material—10 per cent on labor and 15 per cent on material.

The motion was seconded and carried.

C. J. Wymer: There is something in Rule 36 relative to applying missing placards. It says, "Application or removal of such placards or certificates should be charged for on authority of defect card in accordance with Rule 107." Rule 107 does not provide an item for the application of placards. It is all removal. I move that another item be added in there providing a charge for the application of such cards as required by Rule 36.

The motion was seconded and carried.

Rule 111

Mr. Jameson: Rule 111, Item 29: Does the average charge of $4.92 include the material charge for a triple check-valve case, also cylinder piston packing leather expander, J-M type, and triple cylinder applied at the same time that air brakes are cleaned?

M. E. Fitzgerald: May I read an interpretation from the Association: "This average charge covers all labor and material necessary to perform the operation except those items specifically covered in the item itself. No charge is proper for triple valve gasket, either labor or material, when average charge per Item 29 of Rule 111 is made for cleaning brakes."

This is from the secretary of the Association.

Item 29 in Rule 111 clearly defines each operation, both labor and material, and makes no reference whatsoever to the triple valve gasket nor the two or three stud bolts, whichever may be the case, attaching the triple valve to the body of the brake reservoir. Many roads are billing for that item regardless of this interpretation. I move that inasmuch as the items are not properly specified in Rule 111, Item 29, they be considered as billable against the car owner and that also in case of application of J-M. expander, the additional material cost over the ordinary rate be also billable.

The motion was seconded.

Mr. Jameson: Do I understand that to include the triple valve check case and the triple valve cap? The interpretation simply said that the exceptions were all shown. What are the exceptions exclusive of the renewal of the triple valve body? I asked an air brake foreman what a triple valve body was and he told me that it was the cylinder in which the triple piston moves. To make a complete triple valve requires the check case and the cap.

M. E. Fitzgerald: I would not include in my motion any of the parts specified such as check case or front cap. In arriving at the average cost of material and labor necessary in repairing a triple valve, the committee got statements from various roads, showing just what they used and the average was used as a basic price. It includes those particular items, except the triple valve body and so states in Rule 111, Item 29. I merely wish my motion to cover items that are not strictly associated with the repair of the triple valve or the cleaning of the cylinder. It is not necessary to renew a stud bolt or its nut in cleaning the cylinder, neither is it necessary to renew the triple valve gasket. Neither of the items come with either the cylinder or the triple valve if you purchase them, or if you have them repaired in your air room. The work and labor of handling is performed by different men and those items were not included when the average cost price was arrived at.

The motion was carried.

Mr. Jameson: I move that we should get an additional charge for the check-valve case and triple cap when necessary to renew these parts. I do not believe it was the intention to include them in the item of $4.92, Item 29, Rule 111, because it is an extraordinary case when they are broken. Those parts rarely have to be renewed.

The motion was seconded and carried.

Rule 101

M. E. Fitzgerald: We previously discussed labor charges in connection with nipples and the question was raised as to whether or not the price for nipple included the threading. The item in Rule 101 allows 15 cents for a complete one inch or inch and a quarter nipple. Item 29, Rule 111, allows 18 cents for threading the end of a pipe; in other words, two threads, if cut in your yards, would entitle you to a charge of 36 cents and the nipple is only worth, including the material, 15 cents. One must be wrong.

Mr. Owen: A nipple 12 in. long or less is a manufactured nipple; anything over 12 in. we are making an extra charge for cutting the threads on it. This charge of 18 cents is for a thread cut in the yard with a solid die.

M. E. Fitzgerald: In other words, Mr. Owen has a 13-in. nipple, one inch longer than specified in Rule 101, and charges us seven cents a pound for pipe, 36 cents for the threads and gets twice as much and more for his 13-in. nipple than I can get for a 12-in. nipple. I am not objecting to the 15-cent price on the complete nipple, but if he puts on his 13-in. nipple he is going to get 45 cents for it. That is wrong.

Mr. Owen: The 12-in. nipples, or anything under are always carried in stock as a manufactured article. They are cut up in 100 and 200 lots and the threads are cut on the machine where the others have to be cut by hand.

M. E. Fitzgerald: We buy in the open market nipples as long as 18 in., quoted by various manufacturers. I move that this Association consider the rules deficient with respect to nipples, thread cutting, etc., and refer the matter to the A. R. A. rules committee.

The motion was seconded and carried.

A. S. Sternberg: There seems to be a great deal of confusion among the different railroads in preparing bills due to the fact that so few of them get the interpretations and decisions rendered by this price committee of the A. R. A. I move that, since the interpretations on charges in Rules 101, 107 and 111 are rendered by the A. R. A. price committee, we ask that a copy of such decisions and interpretations be mailed to the car departments and representatives of the various railroad companies to enable all concerns to adopt a uniform method of charging and avoid misinterpretations and unnecessary letter writing.

The motion was seconded and carried.

Rule 112

F. H. Hanson: What is meant by that word "Hopper" in the caption at the top of the table in Rule 112, page 157?

C. J. Wymer: I took that up with Mr. Hawthorne and he said it was an error. He said that the word "Hopper" should be in the column with box car.

M. E. Fitzgerald: On page 161, Rule 112, article (d) refers to rebuilt cars. This rule has been in the book for a year and when the Rules Committee made paragraph (d) and referred it to the Association they followed it by requesting or advising that the Committee on Car Construction would provide standard requirements for the rebuilt car. Such standards have never been submitted. We do not know what is a standard requirement for the rebuilt car and we cannot find out from anybody. I move that this Association call to the attention of the Arbitration Committee the fact that we have not received information as to what constitute the strength requirements for a rebuilt car and that they be incorporated in the new rules.

The motion was seconded.

P. M. Kilroy: The Committee on Car Construction has reported recently and their report has been confirmed by letter ballot. That report specifies a draft gear, not of any particular type; it specifies steel ends, it specifies 30 sq. in. of cross section area at bolster instead of 24 sq. in., and a lot of other things. It also provided that when cars went into the shop and required an entire end, that the end should be replaced with either an all steel end or one meeting the requirements as recommended by the committee. That provision failed to pass. All other items, I believe, as reported by the Committee on Car Construction passed and are now in effect.

M. E. Fitzgerald: My motion is still in order inasmuch as we have not gotten any report and they have not complied with the recommendations of the committee.

The motion was carried.

E. Head (Wabash): In the settlement for a car the records cover the age of a car and everything else and the record light weight of the car should have some weight in the matter of settlement. The rule says "Stenciled light weight." We find that the stenciled light weight differs from the record. Just how should we settle that?

A. Kipp: I do not see why his record should not agree with the stenciled light weight.

E. Head: You have not got the same weight on the record that is on your car always. There are cars going around the country without any light weight on them.

A. S. Sternberg: As Mr. Head said, if a car is burned up or destroyed by fire or smashed up in a wreck, you cannot get the light weight; you have to ask the owner for it. His point is that the owner of the destroyed car should be asked to furnish the light weight the same as he is asked to furnish the age of the car.

Rule 120

M. W. Halbert (Chief Inspector, St. Louis, Mo.): The St. Louis Car Foremen's Association recommends that Rule 120 be changed to read as follows:

HOUSE AND STOCK CARS:	
Wooden, with trucks of 60,000 lb. capacity and over, if equipped with metal draft arms extending beyond body bolster, continuous metal draft arms, transom draft gear, metal center sills	$225.00
All steel, *steel underframe*, or steel superstructure frame with steel underframe	315.00
GONDOLA AND HOPPER CARS:	
Wooden, with trucks of 60,000 lb. capacity and over, if equipped with metal draft arms extending beyond body bolster, continuous metal draft arms, transom draft gear, metal center sills	180.00
All steel, *steel underframe*, or steel superstructure frame with steel underframe	270.00
FLAT CARS:	
Wooden, with trucks of 60,000 lb. capacity or over, if equipped with metal draft arms, extending beyond body bolster, continuous metal draft arms, transom draft gear, metal center sills	108.00
Steel underframe	150.00

It is felt that the present rules do not allow enough for making repairs to steel underframe cars.

Secretary Elliott: We want to take "steel underframes" out of each paragraph referring to wooden equipment and add it to the paragraph dealing with steel construction. We feel that there should be an increase in the amount we are allowed before we have to write the owner. I move that we accept those recommendations.

The motion was seconded and carried.

F. H. Hanson: Rule 120, paragraph (e): We ask the owner for authority to repair or destroy the car. I move that we set a time limit of thirty days. We now have cars on our line that have been there for over a year. We are unable to get even replies to our letters from the owner.

The motion was seconded.

C. J. Wymer: Suppose the owner does not answer in thirty days, what is the penalty?

F. H. Hanson: I would say that if we get no reply from the owners inside of thirty days, destroy the car.

Mr. Fitzgerald: I would say if you receive no answer at the expiration of thirty days that you proceed using your own good judgment. You would not want to maliciously destroy a car because the rule gave you the permission to destroy it if the car was worthy of repairs.

F. H. Hanson: It would be assumed, of course, that we would not destroy a car that should be repaired. I dare say that 75 per cent of the cars that we are writing up should not be repaired; they should go into the scrap pile.

We had one particular case that I recall where there were three cars that belonged to a certain railroad and after eight or nine months they finally sent a representative. He called on the foreman who was located at another point and after talking to the foreman and finding out where these cars were stored and had been for months, he said, "I'll take your record, go back and report accordingly." He took back the record that we had already written in the letter.

Secretary Elliott: We find the same condition. We had a car that we wrote up to the owner and after four months he sent his representative down. The representative looked at the car, went away, and we have not heard from him yet. That was four months ago.

The motion was carried.

M. E. Fitzgerald: Rule 120, paragraph (d) reads: "In no case shall the total charge for actual repairs exceed the estimate by more than $50.00 (exclusive of betterment) unless authorized." After you have quoted to the owner the full details and he advised you to proceed with repairs he should accept the bill rendered. Prices in the rules are such that it is a difficult matter for some of the car foremen to estimate. If they are low and they exceed $50 in completing repairs, you must reduce your bill accordingly. I do not think for the difference of $10 or $15 in excess of $50, that there should be questions raised. I move that that paragraph be eliminated and on authority of the owner, repair the car at the cost as per the rules, to eliminate considerable useless correspondence.

The motion was seconded.

F. H. Hanson: I had something in mind along the same line. I was figuring on increasing that $50 to at least $100, but if you cut it out, that is better yet.

The motion was carried.

Chairman Gainey: While it was not the intent of any foreman to mislead the owner of a car written up under Rule 120, still they do it. Just recently I went out to look at a car, checked it with the foreman, asked him where he had the trouble and he said that he did not know. I told him that according to the foot-note under Rule 43 he must tell me how all of this damage occurred when there were more than five broken sills. If you go into the office where the general car foreman is, he looks his records up and cannot find anything on the car. You ask him for his wrecking reports, you run down those wrecking reports and find where this car has been in an accident and should not have been reported under Rule 120.

When you are writing up a car under Rule 120, be sure

that you are right and do not mix your wrecked cars with those under this rule.

M. E. Fitzgerald: Your remarks suggest that a paragraph should be added to Rule 120 referring to the statement which should be furnished under Rule 43. There is no reference there, but Rule 43 refers to Rule 120. I move that a paragraph be added referring to that statement.

The motion was seconded and carried.

Division of the Book of Rules

Chairman Gainey: This Association ought to go on record as recommending to the Arbitration Committee that we have two books of rules, one for the interchange of cars and one for the billing and work done in shops on cars.

A motion to divide the book of rules was made and seconded.

A. Herbster: That raises a question in my mind as to the practice on all roads. On the road that I represent, the inspectors make out the billing and repair card; therefore, they all have to have that same information. They also have the cars destroyed in their territory and have to have that information.

C. J. Wymer: I believe we ought to be confined to one book, but I think it would be well to have it arranged in two sections. *The motion was put to a vote and carried.*

Passenger Car Rules

Rule 8

F. H. Hanson: I move the elimination from Rule 8, Section (e), the words "Cut journal." That is on page 217.

The motion was seconded and carried.

Mr. Jameson: I think when we cut out the cut journals we just did half the work. I move that the slid-flat wheels also be eliminated from Rule 8.

The motion was seconded and carried.

Rule 22

A. Armstrong (Atlanta, Ga.): Item 52, Rule 22, Page 232, gives the value of a new 36 in. wrought steel wheel as $65.84, Scrap, $8.00. If these figures are correct, shouldn't the value of the service metal per 1/16 in. as shown in Item 47, page 231, of the same rule, be $2.41 instead of $2.47? No doubt the bill clerks have caught that.

C. C. Stone: Twenty-four sixteenths at $2.47 amounts to $67.28. Mr. Armstrong wants to know if there isn't an error in the price of the service metal. It should be $2.41 instead of $2.47. There is six cents difference there somewhere.

The meeting adjourned.

Insulation of Freight and Passenger Cars

Theoretical and Practical Considerations; Values of Various Materials; Calculating Heat Transmission

BY WM. N. ALLMAN

THE insulation of heated surfaces in power plants and on locomotives has now become recognized as extremely important on account of the conservation of fuel. In this article, however, another phase of insulation is discussed, namely, that pertaining to the roof and walls of refrigerator and steel passenger cars, each of which will be taken up separately.

It may be said in general that if two adjacent bodies have different temperatures, there is a tendency for one to affect the other, or in other words an average temperature will result. This condition may be brought about by either of the three methods of conveyance, namely, radiation, convection or conduction. These are the methods of heat transfer that must be dealt with in the consideration of the proper form of insulation in the walls of railway equipment cars.

Insulating Material

The study of heat transmission has been given considerable thought in recent years and investigations have been made in order to determine the co-efficients of heat transmission of various insulators. In the application of these co-efficients it is necessary to consider the outside temperature of the air and also the temperature within the car.

In choosing an insulating material, the fact should not be overlooked that it is the most vulnerable part of the construction of the car. Further it must be capable of withstanding deterioration or rotting, and in addition should be free from odors and be vermin proof. Unless it is correctly applied it is very liable to break away after the car has been in service a while, and settle, leaving pockets and air spaces which result in greatly reducing the efficiency of the insulation. Another important feature is that the insulation should be waterproof so that moisture will not collect, thus tending to diminish its ability to insulate.

Theory of Insulation

A heat insulator or non-conductor is a material which by its structure retards or obstructs the transfer of heat. According to this theory there is no material that resists heat perfectly. In recent years, the matter of insulation has been given particular study, and it is now generally agreed that the best insulating value is obtained in a solid form consisting of a large number of interstices or dead air cells, rather than alternating solid layers (without air cells) and air spaces. Formerly the opposite opinion was generally held. However, later experience has taught that the so-called air space construction is seldom built with the care which must be exercised to make such spaces air-tight, and if such spaces have communication with each other, permitting a circulation of air, the real purpose is destroyed by circulation or convection and the efficiency lost. There exist great differences of opinion on this subject of insulation. Jean Claude Peclet in his famous treatise on heat "Traite de la Chaleur" nearly a century ago made some searching experiments on the subject of insulation, and since that time numerous investigations have been made. Notwithstanding, the whole subject is still open to debate. Even the most casual observer can very readily observe the great differences in opinion and in the results obtained, due entirely to the different methods employed in the calculations.

Various experimenters have derived widely different results in their tests on the same type of material and especially in their results for compound walls. Some have not allowed any value for air spaces or for surface resistance, and when these values are omitted, especially on thin combinations, the value given for the section varies greatly. We are therefore face to face with the question as to which method or authority should be accepted as correct.

During the past few years studies and investigations have

been made by numerous engineers. In the writer's opinion there is no further room for doubt and the results, as submitted in treatises by H. C. Dickinson and M. S. Van Dusen, of the National Bureau of Standards, may be accepted as correct.

The question of surface resistance (also referred to as "contact resistance" and "skin effect" by some writers) is being recognized as a most important factor recently, although neglected by some of the authorities on heat transmission. In the following analysis both surface resistance and the value of air spaces are taken into consideration, as this is now generally accepted as being correct.

While it is impossible to prevent entirely the passage of heat through cold storage walls, yet it has been proved that certain forms of construction retard the progress of heat much more than others. A perfect vacuum would be the ideal insulator; this condition, however, does not exist in practice, so the next best arrangement is to provide for still air, or "dead air spaces." Free air is never still, but moves as its density is changed either by a loss or gain in heat, or moisture, or both. In order to secure motionless air, it must therefore be confined, so as to prevent circulation, and in order to provide for this the insulation must be divided into the smallest possible particles and stored in minute cells.

TABLE I.—VARIATION OF HEAT TRANSMISSION WITH AIR VELOCITY

Air Velocity, Ft. Per Min.	B.t.u. Per Hr. Per Sq. Ft. Per Deg. F. Diff.
222	0.130
298	0.133
437	0.137
800	0.159
898	0.169
900	0.170
905	0.170

Heat Conductivity of Insulators

A good insulator must be primarily a good non-conductor, since its chief function is to prevent the flow of heat as much as possible. It must also be capable of withstanding relatively high temperatures without calcining and retain its structural strength in the presence of moisture.

Prof. J. A. Moyer, of the Pennsylvania State College, in tests found that heat transmission varied with the air velocity over the outside of the surface. The results of these tests, made with a corkboard cube, are shown in Table I.

These tests show that the transmission is increased about 34 per cent as the velocity of the air is varied from 222 ft. per min. to 905 ft. per min., or in other words the transmission is changed 5 per cent per 100 ft. per min. change in velocity. From this it will be noted, particularly in railway service, that speed increases the heat transmission consider-

TABLE II—THERMAL CONDUCTIVITIES

Line No.	Material	Thermal Conductivity K×10⁵	Thermal Conductivity k	Density D	Density d	Remarks
1	Asbestos wood	93.0	65.0	1.97	123.0	Asbestos and cement
2	Asbestos paper	17.0	12.0	0.50	31.0	Built up thin layers
3	Balsa wood	10.7	7.5	0.113	7.1	Very light wood, across grain
4	Balsa wood	11.9	8.3	0.128	8.0	Same sample with 13% waterproofing com'pd
5	Balsa wood	11.9	8.3	0.118	7.4	Across grain—untreated
6	Balsa wood	13.2	9.2	0.14	8.8	Medium weight wood
7	Balsa wood	20.0	14.0	0.33	20.0	Heavy
8	Burrash	11.6	8.1	0.14	8.8	Confined with cloth
9	Asbestos mill-board	29.0	20.0	0.97	61.0	
10	Asphalt roofing	24.0	17.0	0.88	55.0	Felt saturated with asphalt
11	Air cell half inch	15.0	11.0	0.14	8.8	Corrugated asbestos paper—enclosing air spaces
12	Air cell 1 inch	17.0	12.0	0.14	8.8	Corrugated asbestos paper—enclosing air spaces
13	Cork-board	9.3	6.5	0.11	6.9	No artificial binder, low density
14	Cork-board	10.4	7.3	0.16	9.9	No artificial binder.
15	Cork-board	10.6	7.4	0.18	11.3	No artificial binder
16	Cork-board	12.1	8.4	0.25	16.0	With bituminous binder
17	Cotton seed—hull fiber	10.8	7.5	0.071	4.4	Loosely packed
18	Cabots quilt (eel grass)	11.0	7.7	0.25	16.0	Enclosed in burlap
19	Ceiba wood	11.3	7.9	0.113	7.1	Across grain—untreated
20	Cypress	23.0	16.0	0.46	29.0	Across grain
21	Cotton wool	10.0	7.0	0.08	5.0	Medium packed.
22	Flaxlinum	11.3	7.9	0.18	11.0	Felted vegetable fibers
23	Fibro felt	11.3	7.9	0.18	11.0	Felted vegetable fibers
24	Fire felt sheet	21.0	14.0	0.42	26.0	Asbestos sheet coated with cement
25	Fire felt roll	22.0	15.0	0.68	43.0	Flexible asbestos sheet
26	Gypsum plaster	80.0	56.0	0.74	46.0	
27	Ground cork	10.2	7.1	0.15	9.4	Less than 1-16 in.
28	Hair felt	8.5	5.9	0.27	17.0	Fibers, perpendicular to heat flow
29	Insulex	19.0	13.5	0.29	18.0	Asbestos and plaster blocks, very porous
30	Insulite	10.2	7.1	0.19	12.0	Fressed wood pulp
31	Keystone hair felt	9.3	6.5	0.30	19.0	Hair felt between waterproof paper
32	Kapok	8.2	5.7	0.014	0.88	Hollow vegetable fibers
33	Lithboard	13.1	9.1	0.20	12.5	Mineral wool, vegetable fibers and binder
34	Linofelt	10.3	7.2	0.18	11.3	Vegetable fibers confined with paper
35	Magnesia—85%	17.5	12.0	0.31	19.0	Magnesia and asbestos
36	Mineral wool	9.3	6.5	0.20	12.0	Loosely packed
37	Mineral wool	9.9	6.9	0.29	18.0	Fibers perpendicular to heat flow
38	Mineral wool	10.2	7.1	0.34	21.0	Firmly packed
39	Mahogany	31.0	22.0	0.55	34.0	Across grain
40	Pure wool	8.4	5.9	0.11	6.9	
41	Pure wool	8.4	5.9	0.10	6.3	
42	Pure wool	9.0	6.3	0.08	5.0	
43	Pure wool	10.1	7.0	0.04	2.5	Very loose packing
44	Oak	35.0	24.0	0.61	38.0	Across grain
45	Planer shavings	14.0	10.0	0.14	8.8	Various.
46	Paraffine	55.0	38.0	0.89	56.0	"Parawax," melting point, 52° C.
47	Rock cork	11.3	7.9	0.25	16.0	Mineral wool and binder
48	Regranulated cork	10.7	7.5	0.13	8.1	About ⅛ inch
49	Rubber	42.0	29.0	1.1	69.0	Soft vulcanized
50	Slag wool	9.0	6.3	0.20	12.0	Loosely packed
51	Sil-O-Cel	10.6	7.4	0.17	10.6	Pulverized
52	Sil-O-Cel	20.0	14.0	0.45	28.0	Infusorial earth, natural blocks
53	Sil-O-Cel	21.4	15.0	0.50	31.0	Infusorial earth, natural blocks
54	Saw dust	14.0	9.7	0.19	12.0	Various
55	Sole leather	38.0	26.0	1.00	62.0	
56	Textan	40.0	28.0	1.3	81.0	Rubber composition
57	Virginia pine	33.0	23.0	0.55	34.0	Across grain
58	Wood felt	12.5	8.7	0.33	21.0	Flexible paper stock
59	Wall board	17.0	12.0	0.69	43.0	Stiff pasteboard
60	White pine	27.0	19.0	0.50	32.0	Across grain
61	White celluloid	50.0	35.0	1.4	88.0	
62	Zenitherm	17.0	12.0	0.26	16.0	Infusorial earth and asbestos.

K = Thermal conductivity in calories per sec., per sq. cm., per degree C., per cm. thickness.
k = Thermal conductivity in B. t. u. per day (24 hrs.) per sq. ft. per degree F., per inch thickness = 69700 × K.
D = Density in grams per cu. cm.
d = Density in lb. per cu. ft. = 62.5 × D.

ably, which should not be overlooked when providing for the proper insulation and B.t.u. losses.

Early Investigations

All investigators have profited by the experiments of Peclet, who was the pioneer in the field. His work was followed by investigations under the direction of the German Government conducted by Herman Iman Rietschel and Franz Grashof. The results of these tests have been translated by John Henry Kinealy and published in 1899 as "Formulas and Tables for Heating." These results still form the fundamental basis for many transmission co-efficients in use at the present time.

Examples and Application of Formulas

As is well known, the transfer of heat can take place by either conduction, radiation or convection. There is quite a variation in the terms applied to the subject of insulation, and in many cases the subject has become very confusing. The following definitions of the terms used in this article are therefore given:

1. *Temperature Gradient*—Temperature difference per unit distance.
2. *Thermal Conductivity*—Time rate of heat flow per unit area per unit temperature gradient.
3. *Thermal Conduction*—Time rate of heat flow per unit area per unit difference in temperature between opposite faces of a slab when the direction of heat flow is assumed to be perpendicular to the faces of the slab.
4. *Thermal Resistance*—The reciprocal of conduction.
5. *Transmission*—Rate of heat flow per unit area per unit temperature difference between the medium on one side of a wall and the medium on the other (the temperatures are assumed to be measured far enough from the material so that the effect of the latter will be unappreciable).
6. *Surface Transmission*—Rate of heat transfer between a surface and the surrounding air, per unit area and unit temperature difference between the surface and the air.

The principal difficulty in all tests for conductivity has been the varying results due to the different methods employed in conducting such tests. In the writer's opinion the

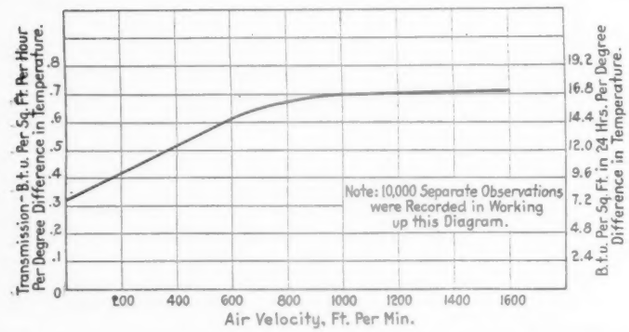


Fig. 1—Heat Transmission of Steel Car Section as Influenced by Air Velocity

Increase up to 700-ft. almost uniform at rate of .0457 B. t. u. for each increase of 100-ft. per minute, or 14% for each 100-ft. per minute increase. Note almost constant increase for velocities 1,000 to 1,600-ft. per minute.

results given by M. S. Van Dusen and presented in the October, 1920, issue of the Journal of the American Society of Heating and Ventilating Engineers can be generally accepted as an accurate basis for determining heat transmission. These values are shown in Table II. In this table are included only those materials that would ordinarily be considered in freight and passenger car equipment.

In the treatment of this subject it has been common recently to refer to the transmission in resistance units instead of conductivity. One unit, however, is the reciprocal of the other, therefore the term "Thermal Resistance" will be adhered to in this discussion. In the analysis of heat transmission it is also necessary to consider that velocity greatly increases the transmission and that another factor is to be considered, namely, surface resistance.

As regards the effect of velocity on transmission of heat Arthur J. Wood has also made some very exhaustive tests in his study on heat transmission with a steel car section. The extent of this investigation may be gathered from the statement that over 10,000 separate observations were recorded and worked up in determining the curve in Fig. 1. It will be seen that the transmission increases almost uniformly up to a velocity of 700 ft. per min. at the rate of .0457 B.t.u. per 100 ft. increase in velocity, or about 14 per cent for each 100 ft. increase per minute.

The matter of surface resistance or transmission is still debatable, but for all practical purposes it is safe to assume a conductivity of 2 B.t.u. per sq. ft. as fairly correct, or in other words a resistance equal to .5, this being the reciprocal of conductivity.

The next question of importance is the subject of air spaces and the value assigned to such. In Table III are given the results of tests made by the U. S. Bureau of Standards, and it is considered that 1 B.t.u. per hour per sq. ft. is practically correct for air spaces in car equipment.

In referring to the theory of the laws governing heat transmission it may be stated that the law of conduction is analogous to Ohm's law for the conduction of electricity. Ohm's law is expressed as follows:

$$I = \frac{E}{R} \qquad (1)$$

or

$$I = EC \qquad (2)$$

where I = Strength of current in amperes

E = Electromotive force or potential difference

C = Conduction of the circuit $= \frac{1}{R}$ or the reciprocal of resistance.

R = Resistance

From the above we then derive:

$$\frac{1}{\text{Resistance}} = \text{current per unit potential difference.} \qquad (3)$$

The rate of heat flow through a surface wall or a compound wall may be determined by the following formulas: For a single wall:

$$H = \frac{T_1 - T_2}{\frac{1}{K} + \frac{d}{C}} \qquad (4)$$

For a compound wall:

$$H = \frac{T_1 - T_2}{\frac{1}{K} + \frac{d}{c} + \frac{d_1}{c_1} + \frac{d_2}{c_2} + \text{etc.}} \qquad (5)$$

where

H = Heat in B.t.u. transmitted per sq. ft. per hour

T_1 = Inside temperature

T_2 = Outside temperature

$\frac{1}{K}$ = Surface resistance = 0.5

d, d_1, d_2, etc. = Thickness of each element in wall

c, c_1, c_2, etc. = Thermal conductivity of elements corresponding to thicknesses d, d_1, d_2, etc., per inch thickness.

In other words the thermal resistance is the reciprocal of conduction and is equal to the thickness of the material di-

vided by the conductivity. After obtaining the sum of all resistances entering into the section the heat transmitted in B.t.u. will be equal to 1 divided by the total resistance. This result in turn will be equal to the total B.t.u. transmitted per sq. ft. per hour per deg. F.

Surface resistance is not so much of a factor in extremely thick walls of great insulating value, but with thin insula-

TABLE III—THERMAL CONDUCTION IN VERTICAL AIR SPACES 8 IN. HIGH

Width of spaces, in.	Temp. diff. 18 deg. F. C	Temp. diff. 18 deg. F. K	Temp. diff. 27 deg. F. C	Temp. diff. 27 deg. F. K	Temp. diff. 36 deg. F. C	Temp. diff. 36 deg. F. K	Temp. diff. 45 deg. F. C	Temp. diff. 45 deg. F. K
.125	50	6.3	51	6.4	52	6.5	53	6.6
.25	32	8.1	33	8.2	33	8.3	34	8.5
.375	26	9.8	27	10.0	27	10.2	28	10.4
.5	23	11.6	24	11.9	24	12.2	25	12.5
.625	22	13.6	23	14.2	24	14.8	25	15.5
.75	22	16.4	23	17.4	25	18.4	26	19.3
.875	22	20.0	24	21.0	25	22.0	26	23.0
1.0	22	22.0	24	24.0	25	25.0	26	26.0
AIR SPACES 24 IN. HIGH								
.5	22.0	11.0	23.0	11.5	23	11.5	24	12.0
1.0	19.1	19.1	20.0	20.0	22	22.0	23	23.0
2.0	18.4	37.0	19.9	40.0	21	43.0	23	46.0
3.0	18.7	56.0	19.7	59.1	21	62.0	22	66.0

C = B.t.u. per 24 hrs. per ft. per deg. F. per inch thickness.
K = B.t.u. per 24 hrs. per ft. per deg. F. for the thickness give in first column.

tion or none at all surface resistance becomes very important as will be observed from the results obtained in substituting the various values in the formulas.

We have previously mentioned that the transfer of heat takes place by conduction, radiation or convection. The conductivity of the different elements is readily obtained from various tables of insulation conductivities but on account of the lack of definite data concerning the other two factors, radiation and convection, they have been generally combined into the one co-efficient of "Surface Transmission" in heat transfer calculations.

For investigations of temperature gradients and other calculations involving the passage of heat the use of heat resistance units should appeal to the modern engineer as in the writer's opinion engineers are more familiar with and recognize these terms.

Insulating Steel Passenger Cars

In insulating steel passenger cars the fact should not be overlooked that the function of an insulator is to keep the car cool in summer and prevent the loss of heat in the winter.

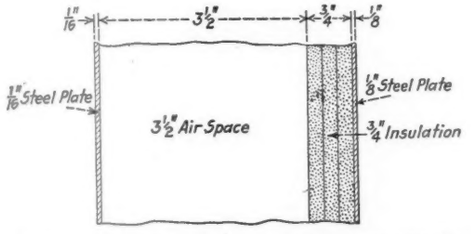


Fig. 2—Representative Section of Steel Passenger Car Wall

Sound deadening is also another important feature as well as the adaptability and permanence of the construction.

The Post Office Department has issued standard specifications for the construction of steel postal cars and under "insulation" is found the following requirement:

> The thermal efficiency of the materials in side and end walls, in roof and in floor must be such that a test duplicate section through walls, roof, or floor (duplicate with the exception of framing members, such as posts, braces, carlines, or stringers, which are to be omitted) will not transmit, when subjected to the test hereinafter described, more than the following amount of heat per sq. ft. or surface in 24 hours for each degree F. difference in temperature between the inside and outside walls of the section.
>
> For side walls, end walls and roof..... 8 B.t.u.
> For floor ..... 7 B.t.u.

In some calculations, due to the small insulating value of the steel plates, these elements have been ignored. In this case, however, the inside and outside steel plates will not be disregarded. The value will be based on a conductivity of 322 B.t.u. per sq. ft. per hour per degree F. per inch thickness.

From formula 5 the following formula, No. 6, is derived when the B.t.u. heat transmission or thermal conductivity is desired for a difference of one degree in temperature.

$$H = \frac{1}{\frac{1}{K} + \frac{d}{c} + \frac{d_1}{c_1} + \frac{d_2}{c_2} + \text{etc.}} \qquad (6)$$

The thermal resistance R will therefore equal the reciprocal of conduction, or

$$R = \frac{1}{H} \qquad (7)$$

In the car section under consideration, shown in Fig. 2, we will assume the outer plate to be 1/8 in. thick and the inner plate 1/16 in. thick, with three-ply Salamander insulation representing a normal thickness of 3/4 in. The value of insulation efficiencies for various insulating materials such as are used in railway equipment cars is shown in Table IV. These figures are the results of tests made by the Union Pacific at Omaha, Neb., in 1914 for the Standard Car Committee. In referring to this table it will be observed that the

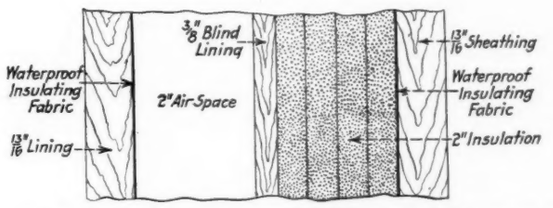


Fig. 3—Representative Section of Side Wall of Refrigerator Car

value assigned to 3/4 in. Salamander is 6.576 B.t.u. per sq. ft. per degree F. difference in temperature per 24 hours or .274 B.t.u. per hour. In view of the fact that the conductivity varies inversely as its thickness the B.t.u. transmission for the unit thickness of 1 in. will be:

$$.274 : X :: 3/4 = .2055 \text{ B.t.u.}$$

Applying the foregoing values to the car section shown in Fig. 2 we have the following:

1/16 in. and 1/8 in. steel plates....	322 B.t.u.
3 1/2 in. Air space (Resistance)...	1 B.t.u.
3/4 in. Salamander	.2055 B.t.u.
Surface resistance	.5 B.t.u.

Substituting in formula 6 we then have:

$$H = \frac{1}{.5 + \frac{.125}{322} + \frac{.75}{.2055} + 1 + \frac{.0625}{322}} =$$

$$\frac{1}{.5 + .000388 + 3.65 + 1 + .000194} = .194 \text{ B.t.u. per hr.}$$

For this typical section this would mean a total of 4.656 B.t.u. transmitted for 24 hours, which is well within the figure of 8 B.t.u., as specified in the Post Office Department specifications as the maximum transmission.

Insulating Refrigerator Cars

The correct insulating of refrigerator cars has been given much thought in recent years, and the subject of insulating efficiencies has naturally been investigated in order to arrive at a definite program for refrigerator car sections. There are a few features which should receive consideration, namely, weight, absorption of moisture, and the adaptability and permanence of the insulation. The importance of a good insulation is therefore well understood, and the first and most

important matter of thermal conductivity of the walls should not be overlooked. During the regime of the Railroad Administration the mechanical department developed a design of car which provides for 2 in. of insulation in sides and ends, 2½ in. in the roof and 2 in. in the floor. In analyzing a representative section we have chosen as an example the side wall of the U.S.R.A. refrigerator car as shown in Fig. 3.

Applying formula 7 and using the following values as shown in Table II, the B.t.u. transmission can be obtained.

13/16 in. Sheathing and lining..... 1 B.t.u. per hr.
2 in. Insulation (basis 4 layers ½ in. Keystone) ..... .271 B.t.u. per hr.
⅜ in. Blind lining ..... 1 B.t.u. per hr
2 in. Air space ..... 1 B.t.u. per hr.

Therefore

$$H = \frac{1}{.5 + \frac{.8125}{1} + \frac{2}{.271} + \frac{.375}{1} + 1 + \frac{.8125}{1}} =$$

$$\frac{1}{.5 + .8125 + 7.4 + .375 + 1 + .8125} = \frac{1}{10.9} = .0918$$

B.t.u. per hr.

or $.0918 \times 24 = 2.203$ B.t.u. per sq. ft. per Degree F. Diff. per 24 hours.

No value has been given to the two layers of waterproofing fabric as this would have very little effect on the result.

There is one point in the construction of the walls of a refrigerator car to which too much value should not be assigned, namely, air spaces. Experience of recent years brings out the fact that it is practically impossible to construct a car with an absolute dead air space, that will remain so, on account of the peculiar stresses and strains to which refrigerator cars are subjected. The real secret of good insulation, therefore, is to adopt a homogeneous insulation containing a large number of enclosed, minute air cells. It should also be understood that the transmission rates arrived at above are for still air conditions and would be greatly increased according to velocity as referred to in the beginning of this article.

CARE OF PIPE THREADING TOOLS.—In order that pipe tools should do the work required of them, they should be made in a manner to assure easy cutting. The lands should be relieved in the thread, as the thread is cut on a taper, and necessarily there must be a large amount of friction. Only by relieving the cutters in the thread can excessive friction be avoided.

When a pipe tap begins to cut hard and tear the thread it is evidence that it is dull and needs grinding. This can be done by the use of an emery wheel of the proper thickness and form of face, grinding the tap in the flute until the cutting edge shows a perfect form. Care should be exercised not to heat the points of the teeth enough to soften them. In the case of 2½-in. and larger taps having inserted lands, the lands can be taken out and all ground to a uniform thickness and replaced. This will assure a uniform cut on each land. When the blades have been ground back so they are no longer safe to use they can be replaced by new blades, as the center is so made that the sets of blades will register and cut perfect threads.

After grinding, all pipe taps should be rechamfered so they will start to cut uniformly.

To keep an ordinary pipe die in good shape is more difficult owing to its form, but not a particle less necessary, as a dull or damaged die will tear the thread on the pipe and cause leaks. The proper way to sharpen a die is to use a small emery wheel or emery stick running at high speed and touch up the cutting edge and chamfer of the die. A die with removable lands can be ground by taking the lands out of the head, grinding the cutting edge and chamfer and replacing them. A receding pipe threader should be used for all pipe 2 in. and larger. Then the chasers can be easily ground and kept in good shape.

The frequency with which taps and dies require regrinding and hence their length of life, is largely dependent upon the use of a suitable cutting compound. A good grade of lard oil is recommended as giving the most satisfactory results. Never use mineral oil as a cutting compound. Rather than use mineral oil, use water or cut with a dry tool.

The usual precautions observed by any good mechanic in the use and care of his tools apply with equal force to taps and dies. Do not throw them around. It will injure the cutting edges. Clean and oil them before you put them away to avoid rust. Keep the flutes clear of chips. Your care will be rewarded by longer life of the tools and greater satisfaction in their performance—*Helix, G. T. & D. Co.*

TABLE IV—INSULATION EFFICIENCIES—TESTS MADE BY UNION PACIFIC FOR STANDARD CAR COMMITTEE, 1914

Name of Insulation	Manufacturer	Thickness in inches	Weight per sq. ft.	Moisture absorbed per cent	Vol. of gas evolved per gram	B. T. U. per sq. ft. per deg. Fahr. diff. in temp. per 24 hrs.	Relative combustibility
Agasote	Pantasote Co.	3/16"	13.58	6.63	137	16.344	Combustible slowly, but will not spread fire
Agasote	Pantasote Co.	¼"	16.87	11.29	....	16.632	Combustible slowly, but will not spread fire
Headlining	Keyes Products	¼"	14.98	8.85	125	15.816	Combustible slowly, but will not spread fire
Headlining	Keyes Products	31/32	19.50	7.91	....	14.328	Combustible slowly, but will not spread fire
Nonpareil Cork Board	Armstrong Cork Co.	½"	4.43	3.63	175	13.344	Combustible slowly, but will not spread fire
Nonpareil Cork Board	Armstrong Cork Co.	½"	8.45	3.27	....	10.368	Combustible slowly, but will not spread fire
Nonpareil Cork Board	Armstrong Cork Co.	1"	14.98	3.22	....	6.576	Combustible slowly, but will not spread fire
Nonpareil Cork Board	Armstrong Cork Co.	2"	27.97	2.44	....	4.224	Combustible slowly, but will not spread fire
Nonpareil High Pres. Lagging	Armstrong Cork Co.	1"	23.77	9.26	Non-Comb.	8.448	Non-combustible
Nonpareil High Pres. Lagging	Armstrong Cork Co.	2"	46.45	10.54	Non-Comb.	5.448	Non-combustible
Magnesite	Pullman Co.	1"	32.41	20.62	....	9.24	Non-combustible
Carline	Franklin Mfg. Co.	1/8"	7.04	4.28	....	16.392	Non-combustible
Carline	Franklin Mfg. Co.	3/16"	8.83	4.85	....	16.32	Non-combustible
Carline	Franklin Mfg. Co.	¼"	9.98	4.84	....	14.448	Non-combustible
Carline	Franklin Mfg. Co.	3/8"	20.42	3.88	....	13.560	Non-combustible
Carline	Franklin Mfg. Co.	½"	23.00	4.34	....	12.192	Non-combustible
Ceilinite	H. W. Johns-Manville	¼"	12.82	6.49	....	15.912	Non-combustible
Asb. Mill Board	Stock	1/8"	11.78	3.72	....	22.392	Non-combustible
Asb. Mill Board	Stock	3/16"	17.30	2.98	....	15.96	Non-combustible
Asb. Mill Board	Stock	¼"	22.87	2.59	....	18.384	Non-combustible
Single Resisto	Gen'l Ry. Supply Co.	¼"	8.10	21.90	....	14.736	Difficult to ignite, but will not spread fire
Double Resisto	Gen'l Ry. Supply Co.	½"	15.44	22.31	....	10.728	Difficult to ignite, but will not spread fire
Nycinsul	H. W. Johns-Manville	¼"	12.52	8.08	70	12.864	Difficult to ignite, but will not spread fire
Nycinsul	H. W. Johns-Manville	½"	13.11	10.75	....	9.52	Difficult to ignite, but will not spread fire
2-Ply Salamander	H. W. Johns-Manville	½"	7.78	8.57	....	7.968	Difficult to ignite, but will not spread fire
3-Ply Salamander	H. W. Johns-Manville	¾"	10.76	8.56	....	6.576	Difficult to ignite, but will not spread fire
Hair Felt	H. W. Johns-Manville	1"	10.53	17.25	....	6.024	Difficult to ignite, but will not spread fire
Steel Car Linofelt No. 1	Union Fibre Co.	1"	17.87	8.37	197	5.04	Easily ignited, and burns readily
Steel Car Linofelt No. 2	Union Fibre Co.	¾"	14.22	6.18	....	6.60	Easily ignited, and burns readily
Steel Car Linofelt No. 3	Union Fibre Co.	¾"	15.90	4.35	....	6.768	Easily ignited, and burns readily
Cabots Quilt No. 1	Sam'l Cabot	5/8"	8.67	28.18	240	7.584	Combustible, but will not spread fire
Cabots Quilt No. 2	Sam'l Cabot	½"	12.47	20.06	....	8.352	Combustible, but will not spread fire
Cabots Quilt No. 3	Sam'l Cabot	5/8"	10.56	24.00	....	7.824	Combustible, but will not spread fire
Flaxlinum	Northern Insul. Co.	¾"	17.05	15.87	187	7.392	Smolders, but will not spread fire
Fireproof Linofelt	Union Fibre Co.	¾"	18.71	9.33	195	7.344	Smolders, but will not spread fire
Fireproof Fibrofelt	Union Fibre Co.	1"	14.83	4.30	95	9.00	Partially combustible, but will not spread fire
Waterproof Lith	Union Fibre Co.	1"	24.50	5.57	190	7.368	Partially combustible, but will not spread fire
Waterproof Lith	Union Fibre Co.	2"	40.39	6.78	....	5.04	Partially combustible, but will not spread fire
Thermo Jacket	Ehret Mfg. Co.	1/16"	12.44	....	....	14.11	Burns
Angora Jacket	Ehret Mfg. Co.	1"	12.73	....	....	7.73	Readily combustible
85% Magnesia	Stock	1"	25.53	....	....	7.94	Non-combustible
Wallbestos	Ehret Mfg. Co.	½"	43.5	....	....	11.02	Fire resisting

Tests of Oxy-Acetylene Blowpipes*

AN elaborate series of tests carried out by the Bureau of Standards, Washington, D. C., on commercial apparatus for oxy-acetylene cutting and welding seems to warrant the following statements:

For the Cutting Blowpipes:

That there is today no generally accepted theory for proportioning, for the cutting of metal of various thicknesses, the volume and velocity of the issuing cutting jet, with the result that none of the apparatus submitted to test proved economical for all thicknesses.

That there is for any thickness of metal cut a limiting velocity of exit of the cutting jet at which complete utilization of the oxygen takes place, and a limiting value for the amount of oxygen required to produce a cut.

That an increase in acetylene consumption, or oxygen consumption, or of the velocity of exit of the cutting jet beyond the limiting values does not produce increased efficiency in commensurate ratio.

That a large majority of the blowpipes tested were equipped with excessive preheating flames for the thickness of metal the tip is specified for, and that such excessive-sized flames are disadvantageous both from the standpoint of economy of operation and quality of work performed.

That considerable improvement in economy of operation seems possible in cutting material of 2 in. thickness and that possibly this condition may be found to exist for metal of other thicknesses than those used in the tests.

That the maximum thickness of metal that may be economically cut with an oxy-acetylene blowpipe of standard design when neither the material nor the oxygen is preheated and the cutting is done only from one direction, is about 12 in.

That the cutting blowpipes due to their incorrect design are subject to the same "flashback" troubles found in the welding blowpipes.

For the Welding Blowpipes:

That the blowpipes most subject to the so-called phenomena of flashback are those in which the oxygen is delivered at a pressure in excess of that at which the acetylene is delivered.

That all the blowpipes tested, including those in which the acetylene is delivered at an excess pressure as well as the so-called equal—or balance—pressure blowpipes, are subject to flashback phenomena on account of inherent defects in their design.

That the cause of the development of the conditions producing flashback is the setting up within the blowpipe tip and head of a back pressure which retards or chokes off the flow of one of the gases.

That this back pressure is the result of confining or restricting the volume flow of the issuing gases at the tip end.

That any cause tending to restrict the flow of the gases sets up a back pressure which immediately causes a change in the amount of each gas delivered to the mixing chamber.

That a fluctuating gas-volume ratio, due to the restriction of volume flow, from whatever cause, prevents a blowpipe from maintaining constantly and at all times during operation the desired "neutral flame."

That a blowpipe that cannot maintain under all operating conditions a neutral flame cannot logically be expected to produce sound welds and is, therefore, unsatisfactory.

That all the blowpipes tested during this investigation either through improper gas pressures or improper interior design or both are incapable of maintaining a neutral flame (constant-volume gas ratio) under all conditions of restricted gas flow and are therefore incapable of producing sound welds where there is any liability of the gaseous products of combustion being momentarily confined such as occurs in practically all welding operations.

That the ability of a blowpipe to consume an equal volume ratio of gases when burning freely and undisturbed in air is no criterion that it is capable of producing sound welds: i. e., that it is not subject to detrimental fluctuations in gas ratio during a welding operation and therefore is

The Foreman and Details

As a foreman how much shoe leather do you wear out in chasing details? Are you studying and managing your department in a big way with a view to getting big results or is your vision being obscured in the effort to adjust numberless details without reference to the problem at large?

How can you dodge an unreasonable amount of detail work? How can these things be made to take care of themselves automatically?

How much time do you spend in cultivating your subordinates and inspiring them to take a greater interest in their work?

*Summary of results of an investigation presented in a paper by R. S. Johnston, Engineer-Physicist, U. S. Bureau of Standards, before the May 23 to 26 meeting of the American Society of Mechanical Engineers at Chicago.

capable of maintaining a neutral flame under all operating conditions.

That whether a blowpipe of present designs will consume an equal volume ratio of gases when burning freely and undisturbed in air depends on how nearly correct the operator sets the so-called "neutral flame," and experience indicates that the average operator checks the acetylene gas flow too much and actually develops an oxidizing rather than a neutral flame.

That the question of the possible limiting strength and ductility or the efficiency of welds made by the oxy-acetylene welding blowpipe must await the development of a more satisfactory instrument, and that having such an instrument there is no reason to believe that a weld of clean, sound metal cannot be made with assurance during any welding operation and that such welds will or can be made to possess the proper physical properties.

Cost of Air vs. Steam for Operating Hammers*

BY G. H. RICHEY

Sullivan Machinery Co.

The basis of data for figuring the amount of air required to operate steam hammers is obtained from the Chambersburg Engineering Company, Chambersburg, Pa. This company estimates that a steam hammer requires 26 cu. ft. of free air per minute for each 100 lb. of falling weight with the hammer working continuously. Where only one hammer is used in an installation, it is necessary to use the constant, 26, but where three or four or more steam hammers are to be operated from the compressor, 50 per cent of the above figure can be used to determine the size of compressor needed. In the case of steam drop forge hammers, 60 per cent of the constant 26 should be used, because these hammers are usually worked harder than the ordinary steam hammers. The air pressure generally is between 90 and 100 lb. per sq. in.

As an example of the method of determining compressor size for a plant, an installation will be considered where there are two 2,000 lb. and one 1,200 lb. steam drop hammers, making a total of 5,200 lb. falling weight. The actual cubic feet of air which would be required to drive these hammers is obtained thus: $52 \times 26 \times .60 = 811$. A 20-12 by 14 in. angle compound, rolling valve compressor was installed. It runs at 196 r.p.m. to give 1,000 cu. ft. per min. This installation carries the hammers easily with an approximate load factor of 75 per cent. The compressor when operating at 196 r.p.m. against 90 lb. pressure consumes 174 h.p. input to the motor or approximately 130 kw. The plant is working nine hours per day and the electric rate is 1¾ cents per kw. hour.

Comparison With Steam Operation

The cost of compressed air power for one day is obtained as follows:

$$\frac{100}{130 \times .75 \times 9 \times 1\frac{3}{4}}$$ equals $15.38 using .75 as the load factor. To determine accurately the amount of steam consumed when used directly in the hammers, of course, is quite difficult. At this plant, from four to four and one-half tons of coal a day was used. Assuming four tons, or 8,000 lb. of coal a day, and an evaporation of seven pounds per pound of coal the pounds of steam per minute per 100 lb. falling weight equals $\frac{5600}{52 \times 9 \times 60}$ or two pounds per min. (approximately). The volume of two pounds of steam at atmospheric pressure is 53 cu. ft., which is to be compared with 12½ cu. ft. of free air, the average amount of air used per min. per 100 lb. falling weight during the day. The above figure of two pounds of steam per min. covers losses due to condensation and coal used in the banking of fires, etc.

At this plant, in normal times, coal costs $6 per ton, which is a cost of $24 per day for the operation of the hammers by steam as compared with $15.38 per day by air. Of course at the present time the coal would cost $10 a ton, which would make the difference a great deal more.

If the amount of air required above was furnished by a 1,000 ft. W. C. (Sullivan Tandem Compound Corliss) compressor running non-condensing, the amount of coal consumed would be $\frac{170\ (HP) \times .75\ (LF) \times 23.5 \times 9}{7\ (EVAP.) \times 2000}$ equals 1.93 tons. Adding 10 per cent for banking fires, etc., gives 2⅛ tons per day. If the compressor is run condensing the coal consumption would be about 1¾ tons per day.

Assuming the cost of coal at $6 a ton as above and allowing $5 for interest, depreciation and upkeep cost per day, the compressor, running non-condensing, shows a saving of $6.25 per day, and running condensing, a saving of $8.50 per day, over running the steam hammers direct by steam.

Changes Needed for Air Operation

Where steam hammers are to be operated by air, it is of vital importance to have the steam hammer piston valve ground to fit its cage. The valves and cages furnished by the steam hammer manufacturers are supposed to be equally good for steam or air but this of course is impossible, since with a large steam piston valve with no rings, a loose fit is necessary to allow for expansion.

It is also quite essential to have a much larger receiver than is usually furnished with the compressor, and a good idea is to have two, one at the compressor and the other as close as possible to the hammers.

Advantages of Using Air

1. The close fitting valve, which can be used on a steam hammer, when operated with air, accounts for a lot of the saving obtained. With loosely fitted steam valves a great portion of the steam leaks through into the exhaust without doing any work whatever.

2. There is no condensation in the pipe lines or in the hammer when operating with air. This condensation, when operating with steam is quite a serious matter and it is general practice to allow the hammers to float (that is, operate on short stroke) in order to keep the hammers warm and cut down the amount of condensation. It is also necessary to float the hammers for about a half hour before using in the morning, to get them heated up. In this method of course there is a great waste of steam, while with the use of air the hammer is ready to operate at any time; and when the job is finished, the hammer may be shut off completely by the valve in the pipe line, thus cutting out the leakage and loss of air when the hammer is not working.

3. When using steam, the piston rod packing has to be renewed once or twice a week, because there is danger that the packing will burn out and allow the condensed steam to fall on the work and on the operators. With air, one set of piston rod packing will last four or five months.

4. With steam there is always a certain amount of hot water dripping down on the men. With air this is done away with, and as the whole hammer remains cold, the machine is much more comfortable for a man to work with. This is especially desirable in changing dies after a job is done.

5. It is a simple matter to lubricate the air hammer and of course a great deal less oil is used than with steam, with which the water washes the lubricant away.

6. A more snappy, lively blow is obtained with air than with steam, therefore, better work is turned out, with an increase in production amounting to 10 or 15 per cent.

7. The exhaust from the hammers can be piped down, to blow the scale off the dies, thus obviating the use of a separate low pressure blower system.

*Abstract of an article in the April issue of Forging and Heat Treating.

Manufacturing Standard Locomotive Repair Parts

A Method of Standardizing and Manufacturing Locomotive Repair Parts in Central Production Shops

BY M. H. WILLIAMS

WHEN manufacturing repair parts for locomotives in central production shops, it is desirable that they be machined to as near the finished state as possible since, owing to quantity production and the use of modern machines, finishing done in this department will cost less than when done in repair shops. In addition, the reduction of finish machine operations in back shops increases shop output and capacity. In order to determine the surfaces which may be finished and their respective sizes, the manufacturing department must carefully study local manufacturing conditions; also the condition of machines and tool equipment in the home and smaller shops where repair parts are to be used, an attempt being made to meet the average requirements of all these shops.

Relation Between Production and Repair Shops

In many respects the relations existing between the central production shop and repair shops is similar to that which exists between manufacturing concerns and their customers. In each case the manufacturer must cater to the requirements of the user and supply goods that will best meet the requirements and unless this be the practice, the shops where these parts are used will not receive the maximum benefits.

It is important to determine the number of articles that may profitably be made at one time in the central shop without overburdening the stock account. The nature of these articles, machines available or contemplated, requirements of repair shops and costs are also important factors. To give a few illustrations, articles that should be made on automatic machines can best be centralized in this shop. Work made on turret lathes should to a lesser extent be centralized depending largely on the number required at one time. Planer work on articles, several of which may be set up on the planer at one time, can as a rule be finished more cheaply in the central shop. Where the nature of the work is such that only one piece can be planed at a time there is not much to be gained by doing this in the large central shop as the work of setting up and machining will be practically the same wherever it is done. Ordinary lathe work can usually be done as cheaply in one shop as another. All that will be gained in the central shop will be the greater output that follows as a result of more modern tools, better supervision, facilities for handling and the use of gages and templets that would be justified for the central shop, but would hardly be warranted in each of the smaller shops.

Standardizing Semi-Finished Parts

In order to standardize the articles to be made, each should be carefully analyzed and a standard set to govern the following: step or grade sizes of bearing surfaces, diameters, tolerances, grades of finish and bearing surfaces that can be finished complete in the central shop. An example of this is the straight body or bearing surfaces of side rod knuckle pins and bushings. When setting these sizes a number of points must be taken into consideration such as the compression of the bushings when forced into the rod and the amount that should be allowed for running fits.

By step or grade sizes is meant the steps in sizes such as 1⅛ in., 1¼ in., 1⅜ in., etc., necessary to allow for wear of the part to which it is to be applied, or where the piece used for repairs must be larger or smaller than called for on the original drawings. Step sizes will apply largely to all motion pins. Surfaces that are to be rough machined at the time of manufacture, the sizes being made suitable to best meet the conditions when fitting to the place intended, include, for example, the taper ends of knuckle and valve motion pins, the outside diameters of bushings for the above, crank pin fits in wheel centers, etc.

In order that nuts shall accurately fit the threaded ends of crosshead pins, crank pins and similar articles, standards and limits should be set governing the maximum and minimum thread sizes. This is important as a number of screw threads used on locomotives are not regular U. S. screw threads. A number of different tapers are used in locomotive work and it is not suggested that these be changed. However, it is quite essential that each shop use gages and reamers of the correct taper; i. e., where the drawings call for a taper of ¾ in. per ft., this should be uniform in all shops. This subject is of interest to the central shop in order that parts produced there shall fit properly.

In order to give the readers the benefit of what has been done in various shops in the way of standardizing articles used for repair work, a few representative cases will be given showing the method followed when working up this data.

Side Rod Knuckle Pins

For parts of this nature some of the surfaces can be finished complete at the time of manufacture in the central shop. For example, these pins can be made to standard lengths, the threads cut, the holes for taper pins or cotter keys drilled and key-ways milled. This part of the machining operation would be the same for pins for a standard new rod or for those made larger than drawing sizes such as are used in rods that have been worn and reamed. This now leaves the two taper ends and the body to be considered. Concerning the two taper ends, it will be assumed that on the score of economy and high grade of repairs, the taper holes in rods when undergoing repairs are reamed barely enough to insure a true taper, and that the knuckle pins will each be individually machined to the correct size to fit these holes. This makes it desirable to manufacture the pins in step sizes which should be slightly larger than required so that they may be drawn from stock at the time of repairs and, with a small amount of tuning or grinding, fitted to the rod. The diameter of the two taper ends will be largely governed by the diameter of the body or bearing portion, the taper used and the length. Step sizes can readily be set for these in the following manner.

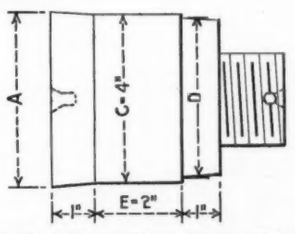


Fig. 1—Typical Proportions of Rod Knuckle Pin

For the purpose of illustration a knuckle pin of the conventional shape and size is shown in Fig. 1 with the diameter of body *C* equal to 4 in., the length of body *E* being 2 in. and each taper end being 1 in. long. The total taper is 1 in. per foot which is regular from end to end. It is evident that

the 4 in. body size can be maintained as long as the small end of the larger taper is equal to or greater than 4 in. and the smaller taper at *D* does not exceed 4 in. Therefore a pin with a 4 in. body can be made to fit any rod coming within this range by machining the two taper ends. Where the rod has been reamed above 4 in. at the taper *D*, it becomes necessary to make use of a pin with a body larger than 4 in. and in this case step sizes should be adopted. In order to reduce the number of step sizes to a minimum, it is advisable to make the advances between the steps as large as the design of pin will admit.

The maximum difference that can be allowed in step sizes as above mentioned will be governed by the taper and length of the body *E*, the formula for which is as follows: taper per inch equals taper per foot divided by 12; maximum step size equals taper per inch multiplied by length of body *E*. With the pin in question the total taper is 1 in. per ft., or 0.0833 in., which equals, when multiplied by 2 (the body length), 0.166 in. This is the largest amount the step sizes can advance from one size to another with a pin of the size and taper shown in Fig. 1 at the same time insuring a full surface on the body *E* and the two taper ends. The above

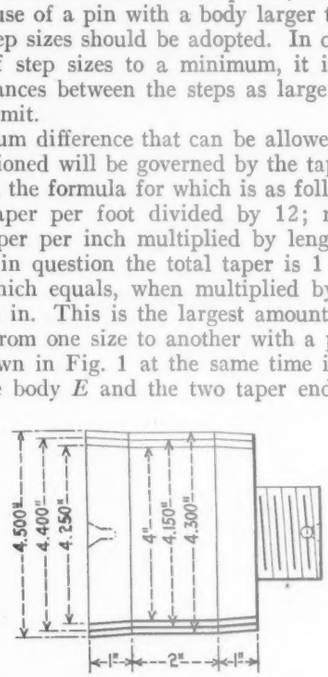


Fig. 2—Proposed Step Sizes for Knuckle Pins

method may be followed for any degree of taper or length of body.

By a similar calculation the maximum size at the large end of taper *A* is found. With the pin in question the distance from the large end of the pin to the smaller taper at *D* is 3 in. Multiplying 0.0833 by 3 equals .250 in. Therefore the greatest possible diameter for this pin at *A* will be 4.250 in., or 4¼ in. Likewise for a pin which is 4¼ in. at the large end *A*, the smallest taper at *D* will be the same as the body, or 4 in. The least diameter of the small taper at *D* will be 0.166 in. less than the body size, or 4 in. minus 0.166 in.=3.834 in. Therefore a pin that has been blanked out 4¼ in. at *A* and 4 in. at *D* can be refitted where the taper at *D* is not larger than 4 in. or smaller than 3.834 in. To make the larger taper at *A* greater than 4¼ in. with a 4-in. body will only result in additional machining at the time of fitting to the rod. It is therefore evident that to meet all conditions the 4 in. body pin should be blanked out in the central production shop with the large taper at *A* equal to 4¼ in. and the smaller taper at *D* equal to 4 in.

The next question to be considered is the largest step sizes necessary when fitting a pin to a rod that has been reamed larger than 4 in. at the taper *D*. It is evident that the pin (Fig. 1) cannot be used as the smaller of the two tapers would not true up. Calculations have shown that for the pin in question the step sizes may theoretically be advanced by 0.166 in. but for simplicity, it is advisable to make use of step sizes agreeing with common fractions or easily remembered decimals. In this case the step sizes may be ⅛ in. or 5/32 in. or, in decimals 0.150 in., this being a question generally settled after going over the requirements for both the pins and reaming sizes for bore of bushings. For the pin in question a step size of 0.150 in. would fit in very well. It is not the purpose at this time to go into the relative merits of common and decimal fractions. However, for such work as fitting knuckle pins and general central production products decimals have decided advantages and where setting step sizes their use is to be recommended.

A taper of 1 in. per ft. has been considered thus far but if a greater taper is called for, such as 1½ in. per ft., the step sizes may be advanced by ¼ in. On the other hand a lower taper will reduce the step sizes. In either case the larger pin will start in where the smaller one leaves off. In some cases, especially where grinding is practiced when fitting the pins to the rods, it is advisable to use two or more step sizes for the taper ends for each body step size. As an illustration in the case of the pins explained having step sizes of 0.150 in., the body step sizes would advance by 0.150 in. and the taper ends by 0.075 in. Fig. 2 illustrates in outline a knuckle pin similar to that shown in Fig. 1 with two larger sizes superimposed on the original. This will serve to show more fully the plan of setting step sizes.

Detail step sizes for knuckle pins such as would be required for repair work are shown in Fig. 3, together with directions for all extra operations, limits, method of manufacture and general information. These lists are generally shown in blue-print form and often show pins for several classes of locomotives on a single print. They have the advantage that at the time of manufacture the central shop will have complete instructions as to the sizes, surfaces to be finished or left rough, etc. Likewise the repair shops will know what is being manufactured. Fig. 3 calls for the pins to be casehardened on all surfaces except the thread, and as a result of following this practice it would be necessary to grind the surfaces when fitting rods. Unfortunately many railroad shops are not equipped with adequate grinding machines and to meet this condition the pins are often supplied ground on the body and carburized, which permits turning the taper ends on a lathe and afterwards hardening. The body being to correct size does not require machining at the time of fitting to the rod, so that this operation is eliminated.

Where the bodies of pins are ground to exact sizes all pins of the same nominal size will have interchangeable bodies and as a result it is not necessary to finish the bodies when used for repairs. Fig. 3 also calls for the body to be ground 0.015 in. larger than the finish size previous to casehardening, this being a practice not generally followed in railway shops but quite common in manufacturing concerns. It is done for the following reasons: the pin or similar article as it comes from the automatic machine or turret lathe will often run out of true on its centers and if casehardened in this condition the grinding will remove a greater amount of the casehardening from one side of the pin. This possibility is avoided by first grinding. Again this rough grinding becomes the finishing operation for the blanking out operation and as a result it is not necessary to hold the blanking operation to such close limits which results in greater output. The

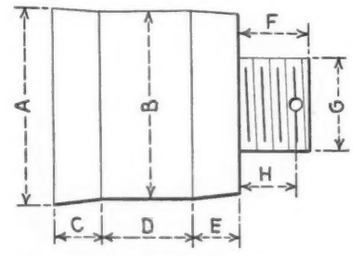


Fig. 3—Knuckle Pin Dimensions in Detail

Class	A	B	C	D	E	F	G	H	
M ..	4.250 in.	4 in.	1 in.	2 in.	1 in.	1½ in.	2 in.	1 in.	Standard
M ..	4.400 in.	4.150 in.	1 in.	2 in.	1 in.	1½ in.	2 in.	1 in.	1st Step
M ..	4.559 in.	4.300 in.	1 in.	2 in.	1 in.	1½ in.	2 in.	1 in.	2nd Step
M ..	4.700 in.	4.450 in.	1 in.	2 in.	1 in.	1½ in.	2 in.	1 in.	3rd Step

Note—Blank out body B between 0.20 in. and 0.30 in. large. Center and grind 0.010 in. large. Casehарden all over except threads. Grind body B to sizes given, using limits of plus or minus 0.001 in. Place in stock.

saving in time when blanking out and the decreased number of spoiled pieces will generally be found sufficient to offset the cost of grinding. Actually the rough grinding on a suitable machine only takes from two to three minutes.

Knuckle Pin Bushings

It is evident that the bore of knuckle pin bushings should, where possible, be finished a definite amount larger than the knuckle pin body at the time of manufacture in order to allow for the necessary running fit between the two. When determining the bore size the fact must be remembered that the bore will be reduced to a certain extent when pressed into the rod owing to compression. In addition, there is the factor of the rod holes for the bushings not being a true circle or regular from end to end which will result in the bore of bushings after application taking to a certain extent the same shape as the rod bore. This irregularity will be governed by the thickness of bushing walls and is a question of the bushing giving way to the rod or vice versa. The amount the bore will compress is generally determined by making actual measurements of bushings before and after pressing in the rod and noting the differences.

The question of tools and appliances in repair shops for the purpose of truing the rod bores will have quite an influence on the proposed bore sizes. That is, if the repair shops are well equipped with grinding machines, adjustable reamers or suitable boring machines for correcting irregularities in the rods, the amount the bushing bore is larger than the pin body can be set with sufficient accuracy so that it may be made right at the time of manufacture, thus meeting the average requirements of pin and bushing fitting and avoiding individual fitting at the time of making locomotive repairs. Where this condition does not exist it is generally necessary to fit each pin to its companion bushing.

On some roads it has been recommended that there be from 0.005 to 0.008 in. lost motion between pin and bushing when the bushing is home in the rod, in order to allow for the flow of oil and the weaving of the rods when in service. To this amount must be added about 0.004 in. to compensate for the closure of the bushings resulting from forcing into place. This indicates that the bore diameter should be from 0.012 in. to 0.015 in. larger than the diameter of the pin body. (The foregoing applies to repair shops that make a practice of truing the rod bores when irregular.)

Bushings which form a bearing for the knuckle pins should be as true as possible. Good practice has shown that the bore should be ground after blanking out in the case of soft

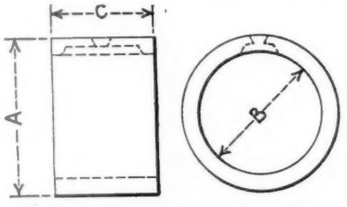


Fig. 4—Step Sizes for Knuckle Pin Bushings

Class	A	B	C	
M.	4¾ in.	4.015 in.	2 in.	Standard
M	4⅞ in.	4.165 in.	2 in.	1st Step
M	5 in.	4.315 in.	2 in.	2nd Step
M	5⅛ in.	4.465 in.	2 in.	3rd Step

Note—Blank out and bore 0.008 in. small. Drill oil hole and mill oil way. Caseharden bore, leaving outside soft. Grind bore to sizes given, using limits of plus or minus 0.001 in. Place in stock.

steel bushings, or ground after casehardening for the hard bushings. Where this grinding is done in the central shop a large number of bushings may be ground in a batch on internal grinding machines at a small cost. The number of step sizes of bushing bore will be governed by the knuckle pin body diameter, that is, they must be some 0.012 in. to 0.015 in. larger than the pin body sizes as shown in Fig. 3. A table of bushing sizes is shown in Fig. 4.

The outside diameters are generally turned when applying in the rod, therefore setting of step sizes will be governed largely by the average enlargement of the rod holes into which they are to be fitted. Generally if these advance by 3/16 in. or ¼ in. all conditions will be met. These sizes are also shown in Fig. 4.

Selective Casehardening

By a process of selective casehardening the bore of a bushing may be made hard and the outside and ends soft, thus making it possible to turn the outside of hardened bushings. This is done in the following manner: After completion of the machine work, the oil holes are filled with fire clay and the bushings filled with casehardening compound, retained in the bushing by caps *A* and *B* and bolt *C*, Fig. 5. These bushings are then placed in regular casehardening boxes, the space between the box and the bushings being filled with burned foundry sand and the box heated in the usual manner. When removing from the furnace, the end caps are removed, the compound emptied out and the bushings quenched. This results in the bore being hard. However, as

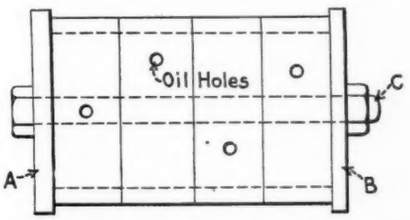


Fig. 5—Arrangement for Case Hardening Bushing Interior

the ends and outside were not carburized these surfaces remain soft and may be turned as readily as soft steel or iron. This process has the advantages of hard center and soft outside that admits of the central shop grinding the bore and any shop applying.

As in the case of knuckle pins, it is advisable to prepare tracings showing the dimensions for blanking out, finishing and other operations such as drilling oil holes, milling oil ways, etc.

Valve Motion Pins and Bushings

It is doubtful whether any part of locomotive repairs should receive more careful attention than fitting the valve motion pins and bushings to the levers and to each other. If there is too much lost motion between pins and bushings the valve will not function properly. On the other hand if they are fitted too closely there is the possibility of heating and binding that often causes engine failures. These pins are comparative small articles that lend themselves to quantity production on automatic screw machines in the central shop where, with suitable machinery, the bushing bores and body sizes of pins can be ground to gage sizes and will properly fit each other. As a result, at time of repairing the locomotive and the work of applying will be reduced owing to these surfaces having been previously finished.

Interchangeability, or the standardization of running fits is important. In some shops it is the practice to fit each pin body to its companion bushing bore and not maintain a standard size for the two and as a result of this lack of uniformity, the levers so joined must be kept in pairs and applied to the same locomotive. This requires individual fitting of these two parts in addition to fitting each to the levers. Where the bodies of pins and the bores of bushings are each ground to standard gages these surfaces become interchangeable and as a result, companion levers need not be kept in pairs; also the pins or bushings may be fitted to the levers independently of each other. This independent fitting is in many respects an assistance to the repair shop

as follows: first, the cost of machining at the time of repairs is reduced on account of eliminating the fitting of the pin body and bushing to each other; second, when several locomotives of the same class are undergoing repairs all similar levers may be repaired in lots, which is more economical than changing from one lever to another for each pin or bushing; third, it is not necessary to keep levers in pairs or place them back on the same locomotive. This interchangeability can be applied to practically all levers with the possible exception of that holding the link block, which is liable to be of varying size and require individual fitting.

Step Sizes for Valve Motion Pins

In many respects valve motion pins and bushings are smaller editions of knuckle pins and bushings and the same general rules will apply. When setting step sizes for bushing bores and pin bodies, it is advisable to consider the number of reamers and gages that will be required and combine the sizes where possible in order to reduce these to a reasonable number. The pins will have bodies of varying lengths and to attempt to make the step sizes as great as the tapers will admit of is liable to lead to complications. Therefore, it has been found good practice to adopt sizes varying by 1/16 in. for the pin body and bushing bore. That is, assuming that the drawings call for bodies 2 in. in diameter, the first oversize is 2 1/16 in., the next 2⅛ in. and so on providing the valve rods are sufficiently large to admit of the extra size without reducing their strength below the danger point.

The smaller of the two taper ends should, as in the case of the knuckle pin, be made in sizes to equal the body and the larger end such size as may be necessary in order to continue the taper from the small to the large end.

The holes for the cotter keys and the key to prevent the pin from turning may be drilled, the end threaded and afterwards casehardened, or where used in a soft state, the body may be ground to standard gage or micrometer size. The taper ends are in some cases ground to step sizes at the time of manufacture so that they may be fitted by simply reaming the lever to the required size. In other cases these surfaces are only rough machined at the time of manufacture and when fitting, the taper ends are ground to fit the levers. Both of these practices have certain advantages. Where the

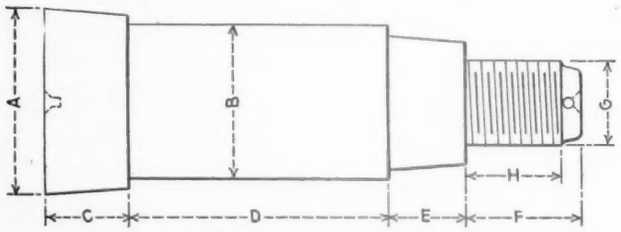


Fig. 6—Step Sizes for Eccentric Rod Pins

Class	A	B	C	D	E	F	G	H	
M	2.250 in.	2 in.	1 in.	3½ in.	1 in.	1¼ in.	1⅛ in.	1¼ in.	Standard
M	2.312 in.	2 1/16 in.	1 in.	3½ in.	1 in.	1¼ in.	1⅛ in.	1¼ in.	1st Step
M	2.387 in.	2⅛ in.	1 in.	3½ in.	1 in.	1¼ in.	1⅛ in.	1¼ in.	2nd Step

Note—Blank out body B 0.020 in. large. Center and grind 0.010 in. large. Casharden all over except threads. Grind body B to sizes given, using limits of plus or minus 0.001 in. Place in stock.

tapers are ground they may be fitted in any shop by simply reaming the levers. To offset this, it becomes necessary to maintain a greater variety of pins of differing step sizes, also maintaining a uniform taper of reamers in all shops. This is at times a difficult problem and another objection is that of enlarging the holes owing to the more frequent reaming which will hasten the time that the levers must be scrapped.

Simply reaming the levers enough to true the surfaces of the holes and fitting the pins to the same will insure a longer life of the levers and reduce the number of step sizes kept in stock. However, where the pins are casehardened it is necessary to grind the taper ends, making grinding machines necessary in shops where these are applied, or resort to selective casehardening. The latter plan of finishing each pin to fit the hole has in practice been found to be the more desirable. The step sizes of eccentric rod pins are plainly shown in Fig. 6.

The nominal diameter of the bore of valve motion lever bushings will be governed by the sizes of pins they are to pair with. The amount that should be allowed for a running fit between the pin and bushing has never been well established for locomotive work. However, in some shops it is the practice to allow from 0.003 in. to 0.005 in. play between these two parts and this practice appears to be satisfactory, it having been found that less than this minimum amount is liable to cause heating or galling, and more than the maximum amount too much lost motion. In addition to the amount that should be allowed for the running fit, an allowance will have to be made for the compression of the bore when forcing the bushing into the lever. As a result of these two, practice has shown that the bore of bushings when completed in the central shop should, as a general rule be from 0.006 in. to 0.008 in. larger than the pin body diameter. When setting step sizes governing manufacture it will be found advisable to keep within these limits.

At the time of fitting to the levers, eccentric rod bushings are turned or ground on the outside to fit the holes. Therefore it is not necessary to maintain close sizes when blanking out. Generally making this diameter in steps of 1/16 in. or ⅛ in. larger than the drawing sizes will be found satisfactory for the average run of levers. In many cases the outside diameter is increased in step sizes similar to the bore. The bushings are made principally from bar stock or seamless tubing. When made from either materal it is advisable to ream the bore at the time of manufacture about 0.010 in. small and finish grind to such diameters as may be determined upon. Where the bushings are hardened the grinding is done after the hardening and should be to close limits and measured and checked with plug gages. While manufacturing, the oil holes may be drilled, oil ways milled and other work that may be necessary performed.

These bushings, like the side rod knuckle pin bushings, may be selectively casehardened as shown in Fig. 5. Where this practice is followed they may be turned and are therefore readily applied in any shop.

Cross-Head and Crank Pins

Cross-head pins are larger editions of side rod knuckle joint pins such as have been previously explained. Therefore the same general methods may be followed when determining upon sizes and planning for their manufacture. These pins except in the larger sizes may readily be blanked out on turret lathes, the keyways milled, ends threaded, holes drilled and such other work performed as may be called for. By determining upon standard diameters for the body such as 4 in., 5 in., etc., this surface may be ground in the central shop to gage or micrometer sizes so that at the time of application to the crosshead the only machine work necessary will be turning the taper ends. This is a point worthy of careful consideration. By making the body to a standard size the front end brasses may, at time of repairs, be bored to a standard plug gage which is a definite amount larger than the pin. This practice will make it possible to use standard boring cutters for all rods to which new pins are applied, and result in the eventual standardizing of this part of the repair work.

In order to provide for badly worn cross-heads or to make use of worn brasses, it is at times necessary to use step-sized pins, but there are so many variables owing to different designs of cross-heads that it would be difficult to set a hard and fast rule to govern all cases. However by carefully

going over the designs and requirements, sizes may be set to cover their manufacture and finish or semi-finish, as may seem desirable.

The larger sizes of crank pins are often beyond the capacity of turret lathes and must from necessity be blanked out on center lathes. However, there are a number of the smaller sizes that come well within the range of the larger turret lathes such as the Steinle, Gisholt, Libby and similar classes. On account of the number of these required it will be found advisable to make a careful study of the possibilities

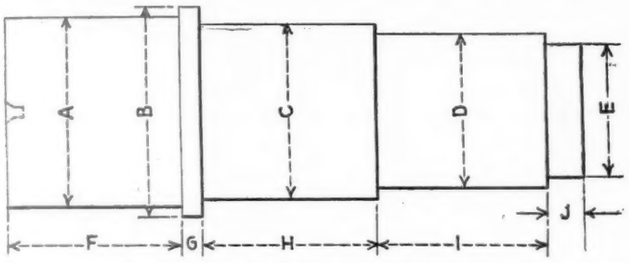


Fig. 7—Step Sizes for Small Crank Pins

Class	A	B	C	D	E	F	G	H	I	J	
M	6½ in.	7 in.	6 in.	5 in.	4 in.	8 in.	½ in.	6 in.	5 in.	2 in.	Front Standard
M	6¾ in.	7 in.	6 in.	5 in.	4 in.	8 in.	½ in.	6 in.	5 in.	2 in.	Front 1st Step

of centralizing their manufacture. One practice followed when manufacturing is to make the pins to correct length, thread, drill center holes in hollow pins, drill holes for cotter or taper pins, finish collars to standard sizes, rough turn the bearing surface about 1/32 in. large and rough turn the portion fitting the wheel center some ¼ in. to ⅜ in. large. After the completion of this blanking out the bearing surfaces are ground to gage sizes. By this process the work of fitting to the wheel center is materially reduced. Fig. 7 shows a form covering crank pins.

(*To be concluded in the August number.*)

Pneumatic Grease Gun

BY NORMAN McCLEOD

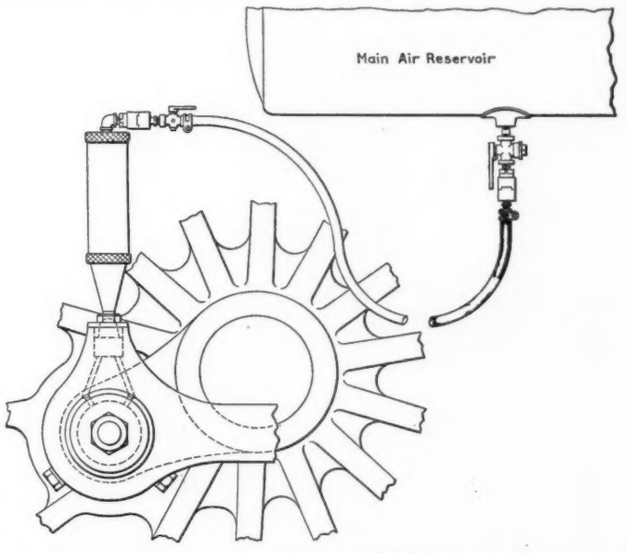
At large locomotive terminals a great deal of time is consumed and engines are often delayed while refilling the grease cups of main and side rods. Cinders and foreign gritty substances get into the cups and finally to the bearings, caused by the present practice of placing caps (which are always full of grease) on the side rods. These pick up foreign substances and introduce them into the cups when the caps are replaced. It also frequently happens that the cups are not easily accessible which necessitates moving the engine. Even then the caps may be difficult to remove, owing to the disadvantage of using a wrench in close quarters. All of the above troubles are eliminated and over one-half of the time and labor is saved by the use of a pneumatic grease gun, such as has been designed and has proved a success on a prominent eastern railroad.

The device consists of a 3-in. brass tube cylinder with a conical shaped end and cap, fitted with a piston and rings, the general arrangement being shown in the illustration. The idea is to have all grease cup caps tapped and fitted with a standard ¾-in. pipe plug, so that the operator with a small wrench (often with his fingers alone) can remove the plug and insert the conical end of the gun. The end of the gun is made to fit loosely into the ¾-in. plug opening, the gun being charged with a 9-in. piece of 3-in. diameter grease which has been previously rolled in graphite. Connection is made to the air reservoir at small engine terminals, or to the permanent air connections at each side of the inspection or ash pits at other terminals, with a ¼-in. hose of sufficient length to reach all cups on the longest locomotive.

The air being turned on at the reservoir, or permanent connection as the case may be, the operator unscrews all ¾-in. plugs and with the gun held vertically proceeds to fill the cups by opening the small ¼-in. standard cock until such time as he feels the gun begin to rise up and out of the cup. He then knows that the cup and passages to the pin are filled solidly with grease. Continuing the operation, all cups are filled in a remarkably short time. The length of the gun permits the operator to reach cups behind the guides or in inaccessible places. It has been found that by the use of the hose coupling shown the work is greatly facilitated. Both the top and bottom heads or ends of the gun are shown to be knurled so that recharging the gun is expedited as they are screwed home by hand.

To refill the gun, the conical end is removed and a 9-in. piece of grease is pushed in, forcing the piston back to its proper place, an air vent taking care of the compression that might otherwise occur. It has been found that rolling the grease in graphite not only reduces the friction in the cylinder, but introduces just enough graphite to make it an ideal lubricant. When it is considered that in a busy time at some of the larger terminals, from 80 to 100 locomotives are handled every ten hours and that twelve men on three tricks, or four men on a trick of eight hours, are required to look after nothing but filling grease cups, this operation is not a matter of small importance.

Another disadvantage of the prevailing method of filling the cups is that frequently much time is lost by the operator



Pneumatic Grease Gun for Filling Rod Cups

in not being able to replace grease cup caps owing to his having tried to put too many cakes of grease into the cup. Mutilation of the thread also is common. By the use of the gun, these and many other similar impediments are eliminated.

When the connection is made to the main reservoir, it is advisable to blow out the reservoir at certain intervals as more or less dirt and sediment collect and ought not to be forced into the grease to later find its way to the bearing. One of the criticisms of the device in its present form is its weight (when filled the gun weighs 14 lb.) and no doubt if made of aluminum it would be considerably lighter. The weight as given, however, seems to be necessary to make the device function properly as it insures the cups being absolutely filled before the gun begins to rise, which is the signal for the operator to shut off the air.

Electric Arc Welding in Railroad Shops

Explanation of the Characteristics of Arc Deposited Metal and Some Samples of Welding

BY A. M. CANDY

General Engineer, Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.

ALTHOUGH much has been written concerning the application of arc welding to railroad equipment, many roads have not applied the process as extensively as possible. There is room for improvement in the quality of electric welds and the best methods of producing consistently good welds are of vital importance to managements, supervisors and welders. With this fact in mind a brief review of the characteristics of good arc deposited metal will be given, showing how metal can be improved by proper procedure and control of the process. A few important applications of arc welding are also illustrated.

Determining the Characteristics of Deposited Metal

To determine the characteristics of arc deposited metal put down under various conditions and in various ways, a number of large masses of metal were built up on steel plates. In one case each layer was brushed off thoroughly with a wire brush and in the other case each layer was cleaned off

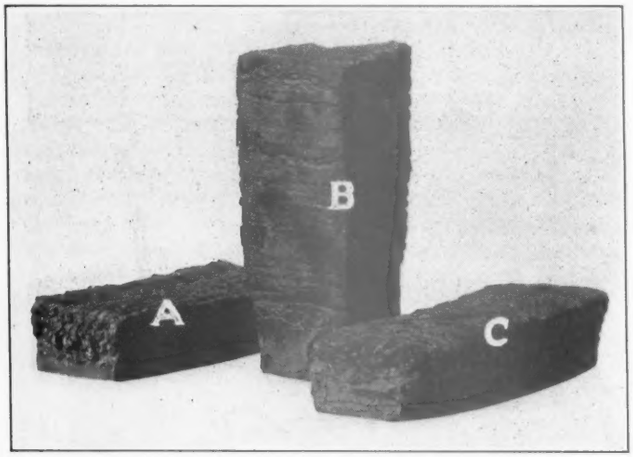


Fig. 1—Deposited Metal Built Up on Steel Plates to Determine Effect of Direction of Metal Deposition on Strength of Weld

thoroughly by sand blasting. Standard 5-in. test specimens were turned out of the solid deposited metal and tested, the results being as follows:

WIRE BRUSHED SAMPLES

Test	Pounds per sq. inch: Ultimate tensile strength	Yield point	Elastic limit	Per cent: Elongation	Reduction of area
No. 1	58,825	41,000	40,000	8.2	19.9
No. 2	54,650	35,000	29,000	6.5	13.4

SAND BLASTED SAMPLES

Test	Pounds per sq. inch: Ultimate tensile strength	Yield point	Elastic limit	Per cent: Elongation	Reduction of area
No. 5	56,075	35,875	29,000	16	23.4
No. 6	58,225	.....	.....	18	27.8

The fractures of all these specimens had the appearance of high grade partially annealed low carbon cast steel. It is interesting to compare tests No. 5 and 6 with No. 1 and 2 and observe that while sand-blasting the layers of metal did not appreciably effect the tensile strength, it did practically double the elasticity of the metal as indicated by the increase in per cent elongation and reduction of area.

To determine the effect of the direction of metal deposition on the strength of a weld, three blocks of deposited metal were built up on steel plates as indicated at *A*, *B* and *C*, Fig. 1. Standard 5-in. tensile test pieces were turned out of these solid blocks of deposited metal. Those from Specimen *A* stressed the metal in the direction of the strings of

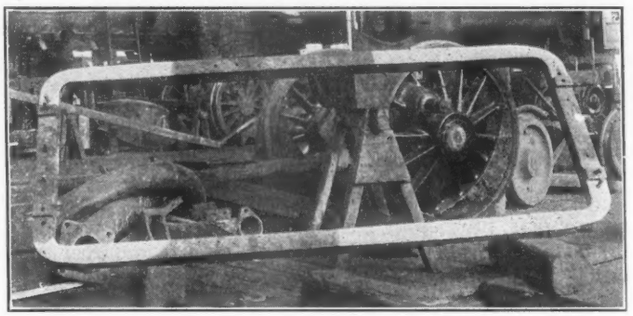


Fig. 2—Locomotive Mud Ring Reclaimed by Arc Welding

deposited metal. Those from Specimen *C* stressed the metal at right angles with the direction of the strings of deposited metal. Those from Specimen *B* stressed the metal at right angles to the layers of deposited metal. The results of the tests on these specimens were as follows:

TENSILE TESTS

Specimen	Pounds per sq. inch: Ultimate tensile strength	Yield point	Elastic limit	Per cent: Elongation in 2 in.	Reduction of area
No. 1	56,000	33,400	27,500	18.1	30.8
No. 1	56,075	35,875	29,000	17.0	23.4
No. 1	58,225	.....	.....	18.0	27.8
No. 3	51,375	29,050	24,000	14.1	18.8
No. 2	40,875	29,400	24,250	4.4	15.9
No. 2	43,500	28,900	20,000	4.9	7.0

COMPRESSION TESTS

Specimen	Load at 10 per cent compression pounds per sq. inch	Elastic limit pounds per sq. inch
No. 1	63,250	32,000
No. 3	60,750	30,700
No. 2	60,700	30,400

SHEARING TESTS

Specimen	Stress at shear pounds per sq. inch
No. 1	39,200
No. 3	41,450
No. 2	38,500

To determine the effect of forging on arc deposited metal, a sample similar to *C*, Fig. 1, was prepared so that standard 5-in. test pieces could be cut from it and leave a sufficient amount of stock for forging before cutting additional test pieces. The results of tensile tests on the unforged and forged portions of this specimen are as follows:

Specimen portion	Pounds per square inch: Ultimate tensile strength	Yield point	Elastic limit	Per cent: Elongation in 2 in.	Reduction of area
Unforged ...	42,187	29,125	22,125	4.6	11.4
Forged	56,900	31,600	28,000	27.6	59.5

It is interesting to observe that the proper forging not only increased the strength of the metal from that of a medium

good weld to that of a very good weld but also improved the ductility to a marked degree, the per cent elongation being increased 500 per cent and the per cent reduction in area being increased 423 per cent.

Examples of Arc Welding on Locomotives

The mud ring of a locomotive boiler which has been badly corroded on the water side in service and which has been re-

Fig. 3—Example of Direct Overhead Welding at Junction of Crown Sheet and Fire Door Sheet in Locomotive Firebox

claimed by building up the corroded areas to their original shape and thickness is shown in Fig. 2.

The appearance of a set of neatly and effectively welded flues is familiar to all and this application of electric welding has proved a big money-saver for roads where bad water must be used. For this work to be successful, however, the

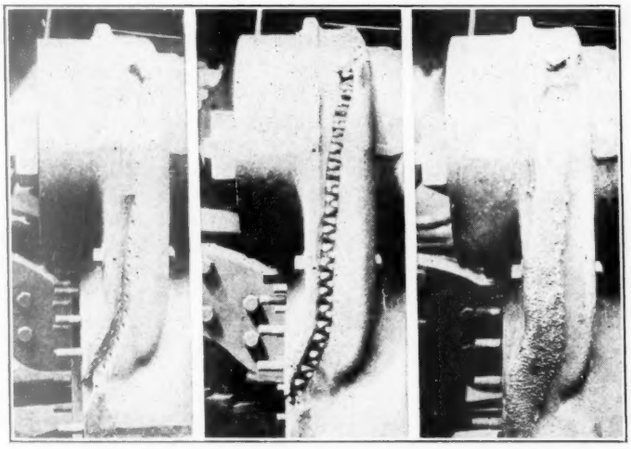


Fig. 4—Locomotive Cylinder Wall Beveled, Studded and Welded

operator must be skillful and know how to get good fusion. Welding flues is a rather exacting operation because the operator is forced to make a partial overhead weld under the lower edge of the tube. Before attempting to weld flues, the operator should make certain that none of the copper gaskets show beyond the edge of the bead. Most operators prefer to start at the bottom center and weld up around one side to the top center of the flue; then start at the bottom center and weld up around the other side to the top center.

A close view of a direct overhead weld at the junction of the crown sheet and fire door sheet in a locomotive fire box is shown in Fig. 3. Direct overhead welding is very difficult and requires an experienced operator with a steady hand and a welding generator which delivers a stable, tenacious arc.

A typical example of cylinder welding is given in Fig. 4 which shows the cylinder wall V-ed out, studded and welded. The greatest advantage (aside from lower cost) claimed for electric over oxy-acetylene welding is that no preheating is necessary. Electric welding is valuable for many building operations such as the eye of a cross head which is badly worn. In this case the welding process is much more satisfactory and cheaper than bushing the hole. Piston heads can be made up of thin cast steel centers and cast iron rims beveled off so that metal fused into the groove to hold the two together, making a steamtight joint. Four holes are usually drilled in the steel centers near the groove and plug welded to give additional strength. Fig. 5 represents a loco-

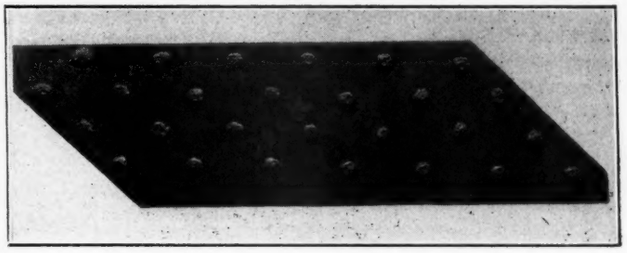


Fig. 5—Corrugations on Deck Plate Built Up by Arc Welding

motive deck plate the corrugated impressions on which have been worn smooth and then built up as indicated.

The shafts of worn journals are sometimes built up by welding, but this is an emergency repair because the deposited metal will not have the same physical properties as the shaft steel. This is evidenced by Fig. 6 which is a section through a typical shaft. This section was polished and etched to show the deposited metal as the white layers on the outside. Immediately below are the block scalloped shapes which are the portions of the shaft affected by the heat of the arc and deposited metal. These portions have been raised above the critical temperature and then rapidly cooled (quenched) by the rapid flow of heat into the main body of the shaft and also through the deposited metal to the air. The dark grey

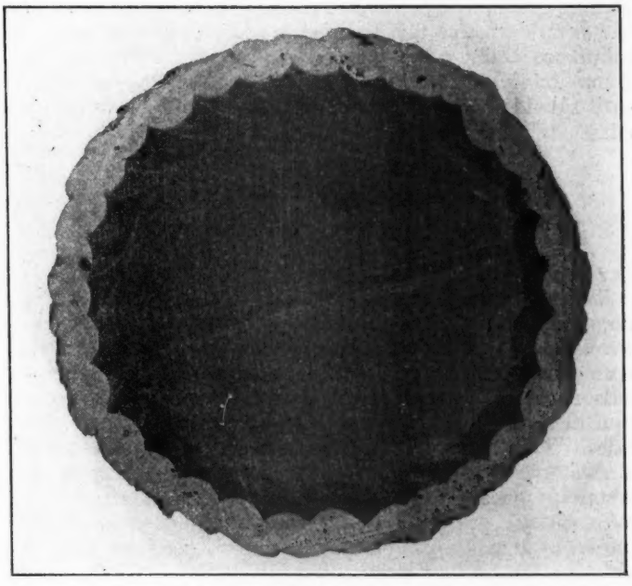


Fig. 6—Section Through Built-Up Shaft Showing Effect of Arc Welding

central portion represents that part of the shaft which has been unaffected. Subsequent heat treatment will reduce the hardened shaft area to its original condition but no amount of heat treatment will affect the deposited metal appreciably. Some very interesting and instructive data along this line

was recently published by T. D. Sedwick, engineer of tests, C. R. I. & P., on page 114 of the February, 1921, issue of the *Railway Mechanical Engineer.*

A car shop kink is illustrated in Fig. 7 which shows a section of car siding with finishing nails welded head on to the plate. Felt lining is pushed over the nails which are then clinched. In doing this work the positive side of the welding circuit is connected to the car body and a pair of pliers is connected to the negative side of the welding circuit.

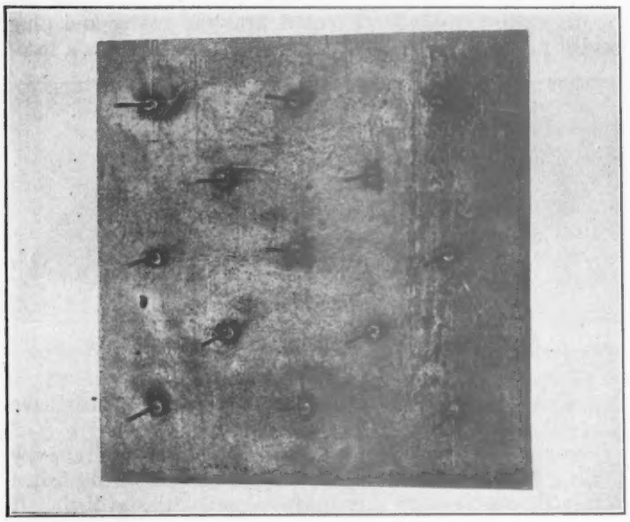


Fig. 7—Nails Welded to Car Side to Hold Felt Lining

The operator grasps a finishing nail in the pliers and touches the head to the plate withdrawing it to form an arc which produces a small puddle of metal in the plate and liquifies the end of the nail. The operator then pushes the nail head into the molten puddle and releases the pliers, leaving the nail welded in position.

Frame welding is another operation in railroad shops affording great possibilities of economy. A valuable feature of the electric arc for this work is the localization of heat, no allowance being necessary for contraction in cooling. In frame welding, quality is of the utmost importance and every care should be taken to improve as much as possible the characteristics of the arc deposited metal.

The Use of Gas in Railroad Shops

BY ROY G. MONROE

Denver Gas & Electric Light Company, Denver, Colo.

To anyone who has watched the setting or removing of large locomotive driver tires, where solid or liquid fuels were used, it is readily apparent that this is one heating operation wherein can be demonstrated most of the inherent advantages of gaseous fuel. It was formerly necessary to heat these tires over wood or forge fires while lying on their sides. This necessitated handling the tires while hot, also a greater expansion to allow for the time lost during the laborious placing of the tires upon the drivers. Later on, burners were devised for using gasoline and other liquid fuels which made possible the heating of the tires while in place on the driving wheels, but which were still far from satisfactory.

It was difficult to adapt liquid fuel burners to the circular shape of the tires; heat control and distribution were uncertain, and the fire and accident hazards were extremely great. Frequently men would be sprayed with burning gasoline or kerosene and several bad accidents occurred in this way. Also it was not uncommon for sufficient burning liquid to run onto the floor to set fire to the flooring some distance from the operation. The caution necessary in handling liquid fuel slowed down production of all the men working in the vicinity, necessitated the assigning of greater floor space to this operation and caused more or less grumbling and dissatisfaction among the men.

Gaseous fuel does away with all of these objections and is also cheaper. The fire and accident hazards are almost wholly eliminated, no accidents or fires being recorded in Denver. The removing and setting of tires by gas is performed on an unprotected wooden floor, a minimum of floor space being used with no additional space required by the heating operation.

Records show consumptions of from 200 to 600 cu. ft. in the expanding of 60 in. by 2½ in. tires, the time varying from 5 min. to 14 min. Tire expanding is done in both the roundhouse and machine shop. Where gasolene or kerosene is used, somewhat in excess of 1½ gals. is required per tire. Improved liquid fuel burners are available which, with careful operation, give but little trouble. Nevertheless gas possesses many advantages in regard to fire hazard, convenience, safety of handling, and storage.

The advantages of gas in the babbitt shop over solid or liquid fuels can be demonstrated very conclusively. Solid fuels require too much time on the fires; liquid fuels burn out the pots, and both fail on account of poor heat control.

A most popular use for gas in this shop is in the pipe heating furnaces, of which there are two, each 30 in. long. The burners are divided into two equal parts, so that if desired gas can be turned on at each end, heating a section of pipe 24 in. long, or gas can be turned on at but one end, heating a section but 12 in. long. A 1½ in. pipe can be heated to a cherry red in but little over 60 sec. These furnaces will heat pipe from the smallest sizes up to 4 in. diameter. A 4 in. pipe packed with sand to keep it from buckling can be heated ready for the bending rolls in less than 10 min. These furnaces heat the pipe with a minimum of scale and danger of burning and are greatly appreciated.

Paint Shop and Car Shop

In these shops the advantages of gas over any other fuel are very important, the principal uses for gas being paint removal with torches, for tinner's furnaces and water jacketed glue pots. Gas for the burning of paint from coaches is much cheaper than any competing fuel and also saves much labor cost. A consumption test demonstrated that 1,200 cu. ft. of gas was sufficient to remove all the paint from a first-class vestibuled coach, including body, sash, screens, doors, etc. A disastrous fire might easily spread to adjoining shops and where coaches and material worth many thousands of dollars are stored. The fire hazard is so great in these shops that gas would be welcomed at several times the cost of any other fuel.

In the tool room, high-speed steel and other heat treatment furnaces for tempering, annealing, case-hardening, pack-hardening, etc., will displace other fuels. It is advisable to use pyrometers and the perfect heat control obtainable with gas, together with the non-oxidizing interior which can easily be obtained in gas-fired furnaces, enables even inexperienced workmen to accomplish good results.

Cutting with Hydrogen Gas.—In an article on the Industrial Application of Hydrogen, H. L. Barnitz points out some of the advantages of the oxy-hydrogen flame for cutting metals. Where hydro-carbon gases are used for this purpose, the carbon unites with the molten metal and causes excessive slag formation. Owing to this tendency gases containing carbon retard the action of the flame, give rough cuts and prevent the action of the flame on the metal from penetrating to any great depth. Hydrogen, on the other hand, gives a speedy, deep and clean cut with oxygen which is not obtainable from all other gases used in conjunction with oxygen as a preheating flame. Iron and steel over 24 in. thick may be cut with the oxy-hydrogen flame.

The Foreman; His Qualifications and Training

Steps Should Be Taken to Find and Fit Men for the Responsibility of Foremanship

BY L. E. GARDNER

DISCUSSION was invited in a recent issue as to the duties of foremen, their prime responsibility, the manner in which they are and should be selected, the training they should receive before and after assignment to such positions, and the placing of the responsibility where it belongs when foremen fail to make good.

These are exceedingly important subjects. Men are more in demand than materials, more difficult to handle and control than machines. The present with its complex industrial conditions, to say nothing of the problems of the future, demands leaders beyond the possibility of past methods to supply. There has been a dearth of leadership. We have been prone to wait for men to come to the front. Some of them have come, but not in sufficient numbers nor with sufficient ability and training to meet the needs. We must go out and find them, and then train and fit them for the work they must do.

Responsibility

The foreman occupies a strategic position. He is responsible for the immediate output of the shop, for securing and maintaining maximum effort and efficiency from each man in his department, and for so co-ordinating and correlating the work of these individual men as to secure the best results from the department as a whole. Without a competent experienced captain or manager to secure teamwork, it is impossible to utilize to the fullest the ability and experience of the individual members of the team.

The foreman is also in a large measure responsible for the loyalty of his men. He embodies to them the corporation, he is the company's man. He interprets company policies. He is the executive with whom the rank and file come closest into contact. As his subordinates respect or disrespect him, so will be their attitude toward the corporation as a whole.

The foreman is also responsible for the care of equipment, for its maintenance and repair, for the installation of labor-saving devices, for the speed of machines and the methods of doing work, for reclamation of scrap and avoidance of waste, for shop operations and processes; safety and sanitary measures also come within the scope of his duties.

The greatest of his responsibilities, however, is for his men, their selection, training, promotion, workmanship, conduct, aspirations, and ideals. In general, he has the right to hire and to fire. To be able to hire intelligently, he must have the ability to judge men, to pick out good material from poor or mediocre, and to recruit his forces with men physically, mentally and temperamentally fitted for the work for which they are being employed. On the other hand, he must know how to exercise the right to fire so as to rid the company of undesirable material, set a proper example for others in maintaining and enforcing discipline, but be able to do it all in a spirit of fairness and justice which will redound to the good of the company as a whole. In addition to selecting and training men for the immediate work, the foreman must also know how to select and train men for promotion, for except where a definite training system is in vogue, the responsibility for making promotions and for the training given workmen and subordinate officials, rests largely with the foreman. Even under a well-organized and supervised training system the foreman is always an important adjunct, if not an actual part, of such organization. It must be borne in mind, too, that it is from their number that higher foremen and other executives are ultimately recruited. Unless the right men are started up the ladder, much time and energy will be wasted and many valuable men overlooked. After all, the foreman is responsible not only for immediate output, but also for ultimate output as well. Without competent supervision and organization only mediocre results can be achieved.

Requisites

Since the duties of a foreman are so important, and his success or failure so far-reaching, let us consider some of the requisites. We will then be in a better position to make proper selection and to decide on the kind and amount of training he should receive.

Among the many requisites in a good foreman, the first is his knowledge of and skill in the work of the men he is to supervise. Without this he is not in a position to give necessary orders or instructions, to properly organize his department, assign the work to be done, intelligently judge the quality or the quantity of work performed by the individual members of his force, or to command the proper respect of his subordinates. Especially is this true in subordinate executive positions, wherein the foreman comes in closest contact with the workmen, where it is necessary for him to set a personal example and often take hold of the work and show the workman how it should be done. A foreman in such a position can undoubtedly secure better results if, having been through the mill himself, he knows of what the daily grind consists, and because of such knowledge and personal experience can hold better the confidence of his men and lead and inspire them to greater effort.

So important is this qualification in a foreman that in the past it often has been considered the only essential qualification and men have been selected solely because of their ability as mechanics, with no thought as to whether they possess the other traits necessary for success. Ability to perform the work of the men being supervised is, however, only one of the many desirable qualifications. Even this is not so essential in higher as in subordinate positions. Railway men are prone to think of engines, shops, and cars, and to neglect the question of men and organization. The chief clerk with natural executive talent, strengthened by experience and association with competent and seasoned executives, combined with his knowledge of the department organization and policies and his knowledge of the men to be supervised may be more promising material than the mechanic who knows nothing but machines.

Qualifications

There are many qualifications to be considered. Perhaps the most essential of all, is the knowledge of men, the ability to understand them, to handle them, to lead and to guide them. Does the man about to be promoted know when and how to give orders, when to give directions, when to merely make suggestions? Does he make a study of human nature? Does he properly sympathize with his men, and is he able to appreciate their viewpoint? Is he honest with both workmen and employers? Does he know when to censure and when to praise, and how much and in what manner this censure or praise should be administered? Is he tactful and diplomatic? Is he fair to all, and yet firm in his decisions

and rulings? Is he self-reliant and resourceful, energetic and industrious, intelligent and quick to learn, ambitious, conservative and yet progressive? Does he possess initiative? Has he enthusiasm? Is his personal character above reproach? Is he popular with associates, both with subordinates and with superiors? Is he a good mixer, yet able to maintain proper dignity? Can be control his tongue and his temper? Is he blessed with good health and physique and vigor? Does he have vitality, steam, go, push? Is he courteous? Is he a dynamic, driving, I-want-it-done-now sort of a man? Has he capacity for leadership, either dormant or developed? Is his personality such that he possesses that consciousness of personal power, that mental poise, that something alive, something dynamic, something electric, something that without effort wins the other fellow mentally and temperamentally, often in both respects? In brief, is he able to create in his men interest in their work, an ambition to excel, a joy and pride in their work? Above all, does he possess, and is he able to instill in his men, intense, unquestioned loyalty to the company? Unless he is himself loyal to the core, willing to sacrifice his own personal gain for the good of the employer he serves, he is unworthy of being considered for advancement.

Men Available in Every Shop

All of the qualifications mentioned or suggested are desirable in a foreman. But no one individual will be found who possesses all the requisites for wise leadership. However, some men possess more of them than others. Some men are blessed by birth and by environment with capacity for leadership. Some have acquired it by training and experience. Still others may possess the dormant talent, which if given proper nourishment and cultivation, will develop beyond expectations. Our duty is to locate the talent, then to develop it. Surely these qualifications are so important, that promotions should not be left to chance or to the favor of an ignorant short-sighted subordinate. Without question the problem is big enough to demand that systematic, well-planned consideration should be given to the picking out of these men and to developing the talents they already possess and to supplying the deficiencies they lack.

In passing let us say that it is not necessary to go outside the company's organization to find men suitable for advancement. There is plenty of good material in any large well-organized corporation for practically any vacancy that may occur, especially if there is a training department or at least some sympathetic executive near by to lend a helping hand in times of troubles. Not all who are tried out can be expected to make good. Neither should a man be condemned for one failure. One successful venture or one dismal failure does not make an ultimate success or an endless failure. Too often when a young foreman falls, some one is ready to knock him down again and gloat over his failure. Of course a successful foreman must be tempered by surmounting his many failures. The testing given him should strengthen him, but a helping hand at the right time may turn a dismal failure into a well-earned success.

Training Needed

Some managements seem to think that foremen are born, not made. It is true some men are born with natural instincts for leadership but these natural instincts must receive training and experience in order to develop. Turn a so-called natural born mechanic loose in a shop to root-hog-or-die and he will learn some things, it is true, but he will fall far short of a similarly endowed young man who has been given a systematic, well-planned course of training. So with leaders. Some will naturally forge to the front in spite of obstacles, but is it not equally true that the average man at least will prove much more capable and efficient if given a chance to profit by a course of training?

Some of the preliminary training may be given before the young man starts up the ladder, but just as the apprentice boy must be given his training while actually engaged on mechanical work, so the training for foremanship must be given while the man is actually working in a supervisory capacity, either in direct charge or acting as an assistant. The executive must be advanced by easy stages from the simple to the complex problems of management. It must be some one's duty to see that the man being trained for foremanship is given experience on the various phases of supervisory work. Men should be tested—not once but repeatedly. It is a waste of time to permit each man to work out each problem for himself. There are so many problems fundamentally alike that each one should be given an opportunity to profit by the mistakes and experience of others.

If there is one thing more important than another that a foreman should learn, it is the importance of having some one trained and ready to take his place. A man's executive capacity is measured by the lieutenants he has to carry out his policies. It is a short-sighted official who is afraid to select too big a man for his assistant. Every man should consider it a part of his work to prepare his successor. Subordinates should be selected with this end in view.

It has been the aim to show the necessity for foremanship training rather than to suggest methods of training, believing that once the importance of the subject is recognized, means will be found for carrying out the project. Among the successful methods being followed by wide-awake managements are the following:

Regular lectures are given foremen, once a week, the lectures and meetings being thrown open for general discussion. In order that this may be well-organized and rapid, sometimes two or three foremen are notified in advance to prepare short discussions. At some meetings stenographic reports are taken. At others certain foremen are asked to give a synopsis of the discussions. In most cases the speaker is an employee of the company, but at times some of the very best men available from outside companies give the addresses. Both classes of speakers are recommended. The company lecture is less expensive, and the speaker being well-known and his ability recognized the employee usually feels a more real and human interest in what he has to say. On the other hand, the outside speaker is often more widely informed, has perhaps specialized on certain topics, and in general is a better and more interesting speaker. At some meetings certain foremen are asked to discuss problems assigned to them in advance. Sometimes problems are assigned and each asked to write out a solution, two or three of the best being read at the meeting. In all cases discussions are as untrammeled as it is possible to make them, each man being encouraged to speak his mind freely and without fear of suffering thereby.

Regular visiting programs have been arranged whereby a foreman in one class of work may visit men engaged in similar work elsewhere. In such cases a report of the visit is made. Sometimes two men are sent together and given suggestions in advance as to what inspections to make or ideas to look for. Men holding similar jobs in different shops are called together for conventions and discussion of matters of common interest. In such cases it is well to give the men opportunity of mingling with each other between formal sessions, for frequently greater benefit is derived from these personal conversations than from the convention proper.

Courses of study have been arranged, these relating definitely to the work over which the foremen have supervision, and being supplemented by sufficient outside work to broaden the man's general training. Too many of our shop foremen are woefully ignorant as to what is going on in the outside world, or even outside of their own department. Some of the subjects discussed are: the products and aims of the company, the policies being followed, biographical sketches of the men responsible for the growth and development of the

company, including those now in charge. The official personnel in general, also the geography of the road. How production may be increased. How co-operation of men may be secured. Safety matters and accident prevention. Sanitation and health. Materials and equipment. Shop processes and operations. Care and repair of machinery. Labor-saving devices. Inspection. Rush jobs. Reclamation of scrap. Expense items. Cost accounting. How data may be secured. Importance of furnishing correct data. What records should be kept. Delays in getting material, causes and results of such delays. Testing materials. Speed of machines. Promotion from the ranks. Governmental control and regulation. Working conditions and their effect on management. The National Agreement. Labor conditions in general. How to secure loyalty and co-operation of men. Discipline. Labor turnover, its cost and prevention. Incentives for good workmanship. What motives actuate men, how may these be supplied? What punishment should be meted out for violation of rules? Piece work and bonuses. Present and future output. Shop betterments. Personnel improvement.

Would not a study of such questions as these serve to broaden and increase the usefulness of the foreman, be he old or young, experienced or inexperienced? Let us repeat, the young subordinate official should not be left to work out all these problems for himself, but rather should be given opportunity under proper supervision for finding solutions for many of these problems before he meets them in actual supervision, and to try out some of the lessons learned. He should not confine his study to books or magazines, nor to advice or suggestions from others, no matter how good they may be, but should study men themselves, not only the men he is to supervise, but men whom he knows have made good. Let him pick out some successful leader with whom he is personally acquainted, and ascertain the secret of his success, what methods he pursues, how he utilizes his time, what his attitude is towards both subordinates and superiors, why he has succeeded while others have failed. Let him be assigned occasionally as assistant to some successful executive willing to give him the benefit of his experience. The prospective foreman can also be tried out to good advantage during the temporary absence of a regular foreman.

The full importance of training foremen is only just being realized. The movement is in its infancy, but is fast gaining ground. Managements are realizing as never before that it is not only possible but absolutely necessary to train men for executive positions.

In a recent investigation of records and plans for the training of foremen, questions were sent to 50 different companies. Twenty-five of these reported having regular plans for training foremen. Many of the others reported that plans were under consideration, with a view of adopting some system of training. Evidently they had felt the need for it. One-third of these companies reported regular meetings of foremen. Where the foremen could not leave their work, the meetings were held outside of working hours. Some of these companies reported regular inspection trips, with reports being made of such trips. Eight reported calling their men together for set lectures, some of these being given by company officials, others by outsiders, both producing good results. Thirteen reported giving regular courses of training to their foremen. Ten reported co-operation with outside educational institutions. Some reported paying the cost of tuition in correspondence courses provided the foremen did regular work on such courses.

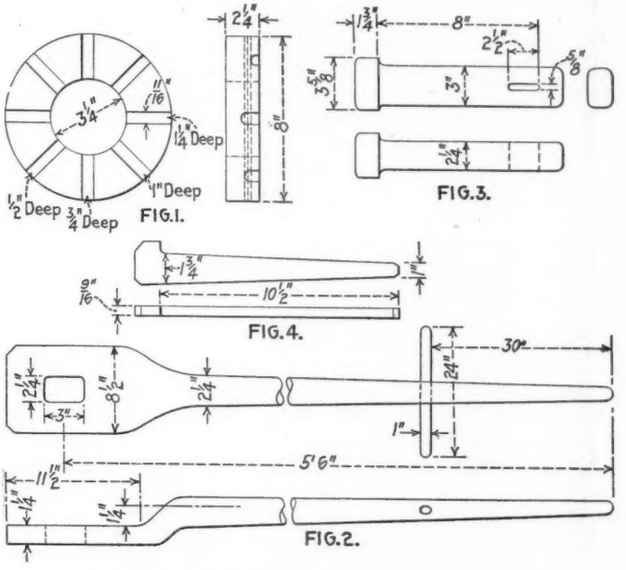
These replies were from manufacturing corporations rather than from railway companies, but the methods pursued are worthy of serious consideration by railway managements. No foreman has a more difficult task than the railway shop or roundhouse foreman. No other corporations are in greater need of competent supervisory forces than are the railway companies today and the need will be even greater in the years to come. Competent foremen cannot be trained over night. The period of training should extend over many years, the more the better. Now is the time to begin. Railway managements may well give the subject serious consideration. Successful foremen are not born, they are made. Those born with talents of leadership must be given an opportunity to grow and develop. Some of them should be transferred to other shops. At least their talents should be cultivated so as to bring out the best that is in them. The results accomplished will more than justify any effort that may be made to meet this situation. The question of leadership is one of the biggest problems the railways have to solve. May it receive the attention and consideration it deserves.

Holder for Side Rods and Drawbars

BY M. C. WHELAN

Foreman Blacksmith, St. Louis-San Francisco, Kansas City, Mo.

For holding drawbars, side rods and other parts while forging, the arrangement illustrated has proved both convenient and readily adjustable to different sizes of work. The difficulty of using tongs is eliminated and heavy parts can be handled at the hammer with maximum ease. The

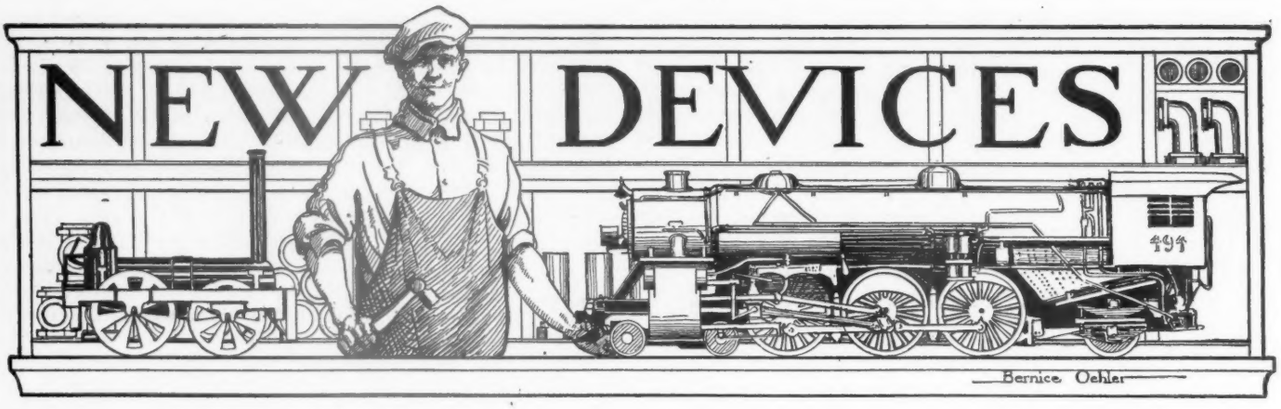


Device for Holding Drawbars While Being Forged

device is safe to operate and cheaply made, the parts being plainly shown in the illustration. They consist of a forged, offset handle (Fig. 2) with one end flattened and provided with a 2¼ in. by 3 in. hole. Fig. 1 shows the heavy washer which is held in place by the pin (Fig. 3) and taper key (Fig. 4). To give a greater purchase in revolving the drawbar or rod, an auxiliary 24 in. crossbar made of 1 in. round stock is applied through the handle, as shown in Fig. 2.

When this device is used for holding side rods in the forging operation, a bushing is placed in the solid end of the rod and the washer, pin and taper key applied as usual. A ram may then be used to upset the rod without injuring the brass bushing in any way. This device can be used in forging many other parts of locomotives and cars, enabling them to be held firmly and accurately.

THE SAFETY DEPARTMENT of the Missouri Pacific, which is conducting a campaign to reduce accidents among its employees, awarded first place in its "Safety First League" to the shops at De Soto, Mo., for the month of May. During this period the 382 employees at the De Soto shops worked without an injury of any kind.



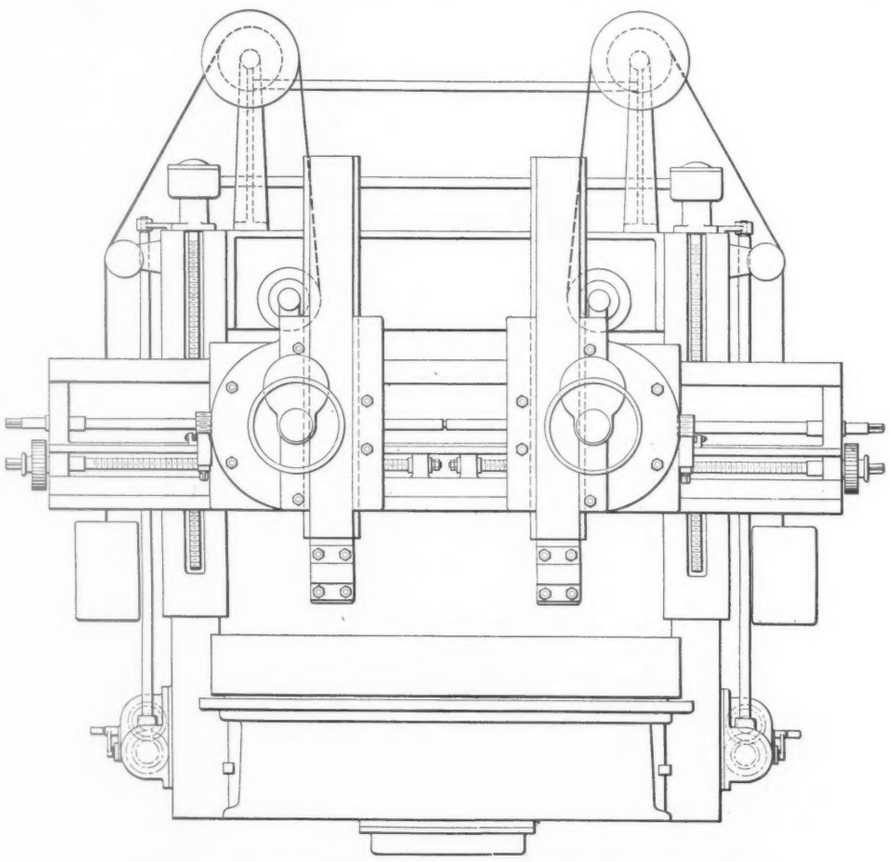
High Power Vertical Turning and Boring Mill

FOR turning and boring operations on locomotive wheel centers and tires, the Colburn Machine Tool Company, Cleveland, Ohio, and the Dale Machinery Company, New York, have recently co-operated in developing the high power, 90-in., boring mill illustrated. The first six machines of this type were built on order for the American Locomotive Company, this firm's standard specifications for heavy duty wheel boring and turning mills of the movable cross-rail type, being adopted as a general guide for the designers.

The design of the mill follows established practice in the construction of machines of the movable cross-rail type but with several new features as follows. Power is delivered to a single pulley from a 42½-h.p., 3-1 variable speed motor which runs on a 220-volt direct current circuit. The driving pulley, shown at *A* in the cross sectional view is 44 in. in diameter by 12 in. face width, and carries a 10-in. belt. This pulley runs free on its shaft, connection to the gearing being accomplished by means of an Edgemont clutch *B* of the disc type, which will transit over 100 h. p. The chief advantage of this arrangement is that the clutch is disengaged, and the brake *C* applied with the same lever, making it unnecessary to overcome the momentum of the high-speed motor armature, driving pulley and belt. This allows the operator to stop the table instantly or move it around slightly when setting tools or work.

From the driving pulley, power is transmitted through gears which are enclosed in the bed of the machine and run in oil. Provision for efficient lubrication is one of the important features of this boring and turning mill. Feed lubricators are used to deliver a constant supply of oil to the spindle drive gears and feed change gear, thus assuring their efficient operation and largely eliminating the personal equation. All gears are made of steel with cut teeth, so that they possess ample strength and durability. The full back gear ratio is 104 to 1 with a maximum gear speed of only 1,064 ft. per min. The table is driven by a pinion *D* meshing with an internal gear which affords an advantageous condition of tooth contact.

The machine is designed to take a maximum feed of ½ by ⅛ in. in steel, with a cutting speed of 60 ft. per min. In working out the design, the fact has been constantly borne in mind that this machine is intended for severe service, and the construction worked out accordingly. The bed is of box form, reinforced with ribs and flanges, a cast-steel trough surrounding the bed to catch cutting compound as it drips from the table. Large fitted bolts connect the bed and housings, which are also of box form, reinforced with ribs and flanges. The spindle is mounted on the table and has a suitable tapered bushing in the bed, provided with means of adjustment to compensate for wear. A powerful built-in

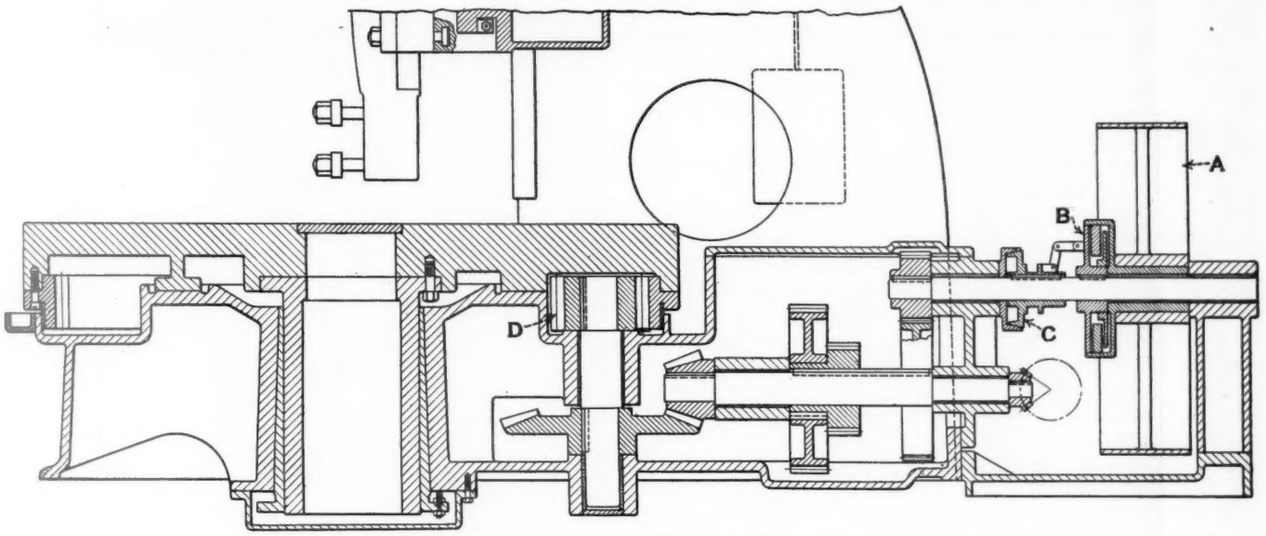


From View of Colburn 90-In. Vertical Turning and Boring Mill

independent four-jaw chuck is provided on the table. In common with other gears in the drive, the table gear and pinion run in oil. All gears and other running members of the mechanism are effectively guarded.

A 5-hp. independent motor provides power for elevating and lowering the cross-rail, which is equipped with two independent saddles, made right and left hand to adapt them for working close together. Either saddle may be moved to the center of the table for use in boring operations. All wear between the cross-rail and saddles, except on the face of the cross-rail, may be taken up with cast-iron gibs. The cross-rail is of the narrow guide type, being made of cast-iron. The saddles are made of steel. The rams are provided with cut rack teeth, and both swivels have adjustment up to 30 deg. on each side of the vertical position. Swivelling is accomplished by means of a worm and ratchet adjustment. Rapid hand movement is provided for the rams and they are equipped with counterbalances, arranged to exert a direct pull on the rams in any angular position. The machine is flexible and special attachments such as power cross feed can be readily applied if desired. The idea, however, has been to eliminate expensive attachments not essential to the special purpose for which this machine was designed. All feed gears are made of steel with cut teeth and the feeds are reversible. Changes of feed are accomplished by sliding gears and clutches.

The dimensions of this machine include: Maximum swing, 91½ in.; maximum distance between table and cross-rail, 46 in.; spindle travel, 42 in.; diameter of table, 87 in.; diameter of track, 52 in.; width of track, 6 in.; diameter of spindle, 18 in.; length of spindle in bearing, 28 in.; table speed with back gears in, 1½ to 4½ r.p.m.; table speed with back gears out, 6 to 18 r.p.m., number of available table speeds, 32; minimum vertical feed, 0.037 in. per table revolution; maximum vertical feed, 1⅛ in.; minimum horizontal feed, 0.022 in.; maximum horizontal feed, 0.672 in.; number of available vertical and horizontal reversible feeds, 8; approximate weight, including the motor, 67,000 lb.



Cross Section Showing Table Support and Driving Mechanism

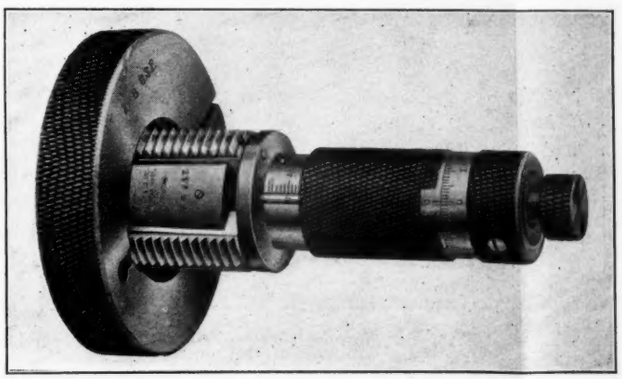
Expanding Internal Thread Micrometer

A UNIQUE tool for measuring internal threads easily and accurately has been developed by John Bath & Co., Inc., Worcester, Mass. This tool, as shown in the illustration, is distinctly a thread micrometer, giving the size of a tapped hole, ring thread gage, or other internal thread directly in units of ten-thousandths of an inch.

The four measuring jaws are supported and held in alinement by close fitting dovetail slots in the body of the micrometer, which is movable by a micrometer screw. The moving parts are lapped and fitted without play and the micrometer is said to be as rigid as a solid plug. This rigidity enables different persons to secure the same measurement on a given piece.

Adjustment is provided so that when wear occurs on the measuring jaws the micrometer may be referred to the master reference ring, set correctly to size, and the wear taken up on the graduated collar.

Where holes are tapped or threaded in quantities, this internal thread micrometer should be especially valuable. By its use the action of taps with different lubricants and cutting compounds, the amount a tap cuts oversize, the effect of every thousand pieces as regards tap wear, and many other conditions may be known, accounted for and corrected. In addition, the need of numerous trial plugs, checks and thread gages will be eliminated. The micrometers can be furnished with any number of threads per inch and in different sizes ranging from 1 in. to 5 in. in diameter as may be desired.



Bath Internal Thread Micrometer and Master Reference Ring

Sixty-Inch Lathe of Exceptional Power

THE 60-in. triple-geared engine lathe, illustrated, is a powerful machine recently completed by the Houston, Stanwood & Gamble Company, Cincinnati, Ohio. It is made with a 42-ft. bed in one section but can be provided with any length of bed ranging from 12 ft. to 42 ft. in 2-ft. steps. The large steady rest, shown, has a capacity of 23 in. to 37 in., being equipped with bronze shoes. The smaller steady rest has a capacity of 2 in. to 23 in. and is also equipped with bronze shoes on the jaws. The lathe may be furnished in a variety of drives, including cone, variable speed motor, constant speed motor, or single pulley drive. The illustration shows a 35-hp. variable speed motor operating on 220 volts direct current.

The rugged construction of the head-stock and arrangement for geared motor drive is plainly shown in Fig. 1. The different positions of the handwheel and levers are indicated by letters which allow the operator to check up the speeds in connection with a speed plate mounted on the head-stock. The reverse plate, quadrant and all levers are made of steel castings. The head-stock gears are made of .50 carbon steel in the majority of cases, having stub teeth cut with a pressure angle of 20 deg. The internal ring gear is made of a ring forging without weld. Forced lubrication of the head-stock is accomplished by means of a pump mounted at the rear of the lathe and belted to the motor shaft, oil gages and indicators showing the operator at all times whether the oil is circulating properly.

A good idea of the arrangement and rugged proportions of the carriage also is given in Fig. 1. The front and back portions of the apron are tongued and grooved through the center in male and female sections, being doweled and substantially bolted together. This construction provides practically a solid apron with no chance of the bearings shifting or getting out of alinement. All gears are of steel, cut with a coarse pitch and wide face. A patented positive angular tooth clutch drives the feed mechanism and allows the operator to engage and disengage the feed instantly under heavy cuts, without excessive strain on the operator's wrist or hand. The rack pinion and rack of heat treated steel are designed to more than meet the demands of the heaviest feeds taken.

The full swing tool post shown in Fig. 1 is mounted on the left of the carriage. A small rapid traverse motor and controller, mounted on the left of the apron provides power traverse by throwing in the lever directly in back of the hand wheel which engages a friction clutch. By moving this lever towards the operator, a positive clutch is engaged, allowing the carriage to be traversed by hand. The controller is so constructed that the operator must hold the handle in position when operating this motor since it will spring back to neutral position as soon as released.

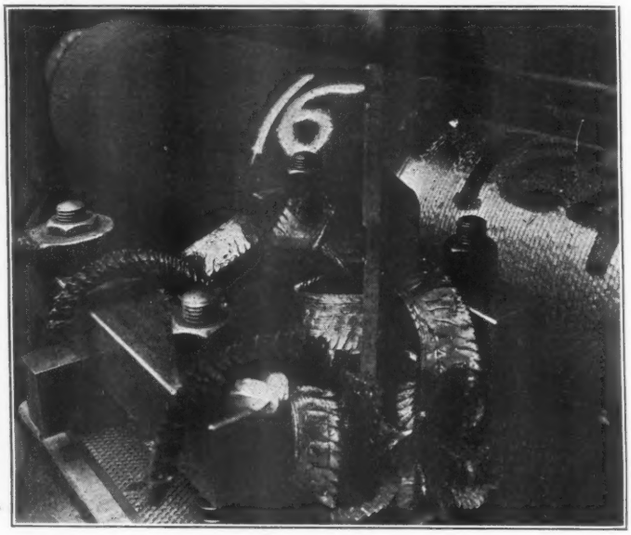


Fig. 2—View Showing Chips Taken in .50 Carbon Forging

The apron motor controller bracket and dial are shown mounted on the right of the apron. This bracket controls the starting, stopping and reversing of the main motor, the action being transmitted through the horizontal shaft (shown near the bottom of the lathe) to the controller by a chain and sprocket. A long ratchet lever at the left of the apron is used when it is desired to exert great power on hand adjust-

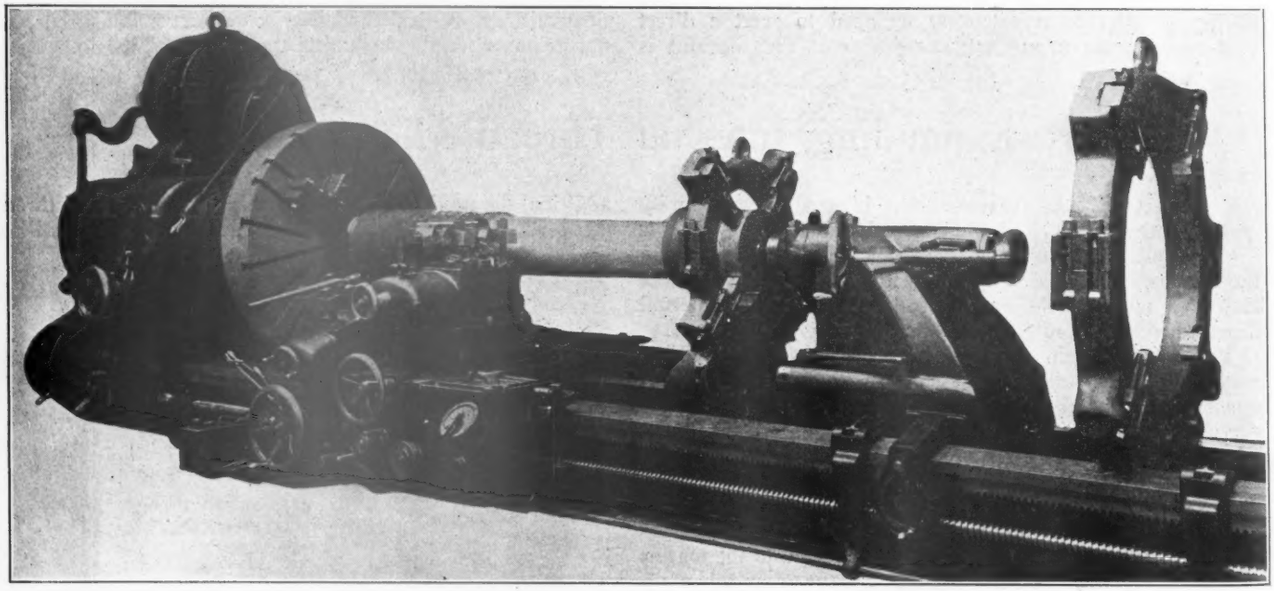


Fig. 1—Houston, Stanwood and Gamble 60-In. Engine Lathe Designed for Heavy Duty

ment of the carriage or when feeding the carriage along the bed under heavy cuts.

A patented support for the lead screw and controller rod is illustrated. It has a bronze bearing for the screw feed rod and may be fastened to the vertical hanger by means of a large cap bolt, being accurately located by two dowels. This support can be easily and quickly removed from the bed and replaced at any position along the bed length.

Some idea of the power of this lathe may be obtained by reference to Fig. 2, which shows the big chips taken in a .50 carbon, hammered forging with a manganese content of 0.68 per cent. The illustration shows a 3¾ in. reduction in diameter of the forging. The cut was 1⅞ in. deep, the feed being ¼ in. and the cutting speed 15 ft. per min. The ammeter during this time registered from 230 to 275 amperes, which at 220 volts indicated a power input to the machine of 75 to 80 hp. After running this cut for 10 or 15 revolutions of the forging, the lathe was stopped. To try the maximum power of the lathe it was immediately started again with the cutting tool underneath the full depth of cut. Under this enormous load the motor started, with the result that a 2 in. by 3 in. high speed steel tool was broken off. When this occurred the ammeter showed from 400 to 500 amperes and the fuse blew out. The test demonstrated the ability of the lathe to withstand the heaviest cutting feeds and speeds utilized in modern practice.

Rail Washer Reduces Flange and Rail Wear

WORN flanges on locomotives and worn, slippery rails are sources of much annoyance and expense to railroads, the trouble being accentuated especially where grades and curves predominate. Numerous devices have been tried in an effort to lubricate satisfactorily the contact between flanges and rails, and these flange lubricators are

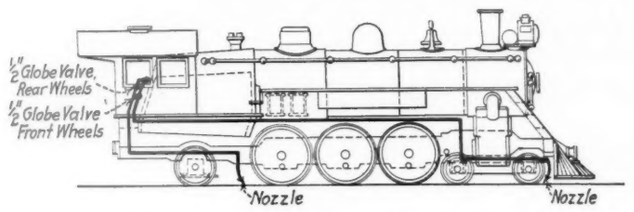


Fig. 1—Application of Rail Washer to Locomotive

quite satisfactory, providing the grease or oil does not feed so fast that it covers the tread of the wheel, or the ball of the rail, and causes slipping. Besides oil flange lubricators, there are also rail-washing devices.

The El Paso & Southwestern has had on some of its locomotives for several years (practically all being now equipped) a type of rail washer. This is a device, patented by J. M. Riddle, engineman, Alamogordo, N. M., using hot water from the boiler, which not only serves to lubricate the wheel flanges and rail, but, as the name implies, serves also to wash or remove sand from the rail after the drivers have passed over. Its application to a locomotive is shown in outline in Fig. 1. A ½ in. pipe is tapped into the back

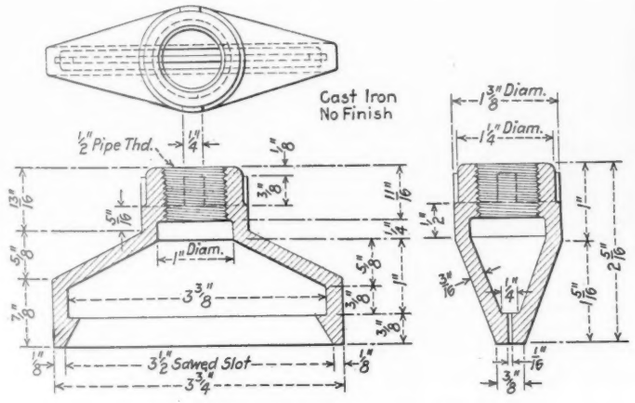


Fig. 2—Cast Iron Rail Washer Nozzle

head of the boiler several inches below the water line and two pipes branch off from this main connection, one leading just ahead of the front engine truck and the other back of the rear drivers. These pipes are extended to within about 6 in. of the rail on either side of the locomotive and have small cast iron nozzles, shown in Fig. 2, at the end of each. On locomotives having trailers, the pipes to the rear wheels are applied just ahead of the trailers with the nozzles pointing slightly forward.

The main connection to the boiler and each branch pipe therefrom are provided with valves accessible to the engineer which may be opened or closed at will, depending upon whether water is to be applied ahead of or behind the drivers. The main valve consists of an ordinary globe valve having not more than a ¼ in. opening into the boiler. A larger hole produces too great a pressure of water against the rail and is likely to blow out the flexible hose connection at the engine truck. Hot water thus applied not only serves as a lubricant between the wheel flanges and rails, but also neutralizes the effect of a frosty rail. It is said that on some of the grades of the E. P. & S. W. the use of this rail washer has made it unnecessary to double-head trains going over a grade and on branch lines, where curves are numerous, flange wear is reduced to a minimum and

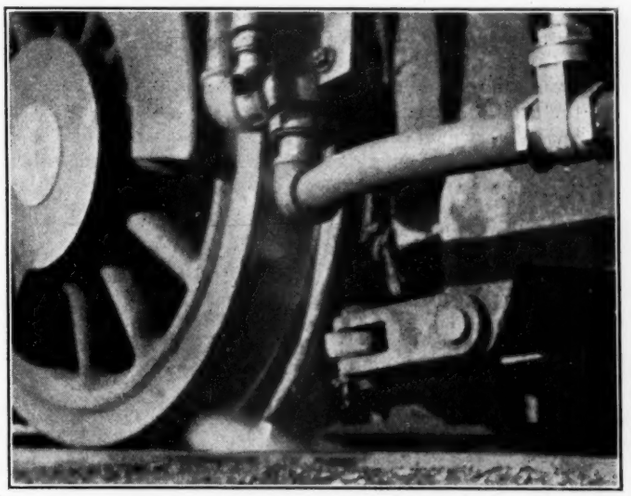


Fig. 3—Rail Washing Device in Operation

there is less danger of derailment. The device is said to be inexpensive to apply and maintain.

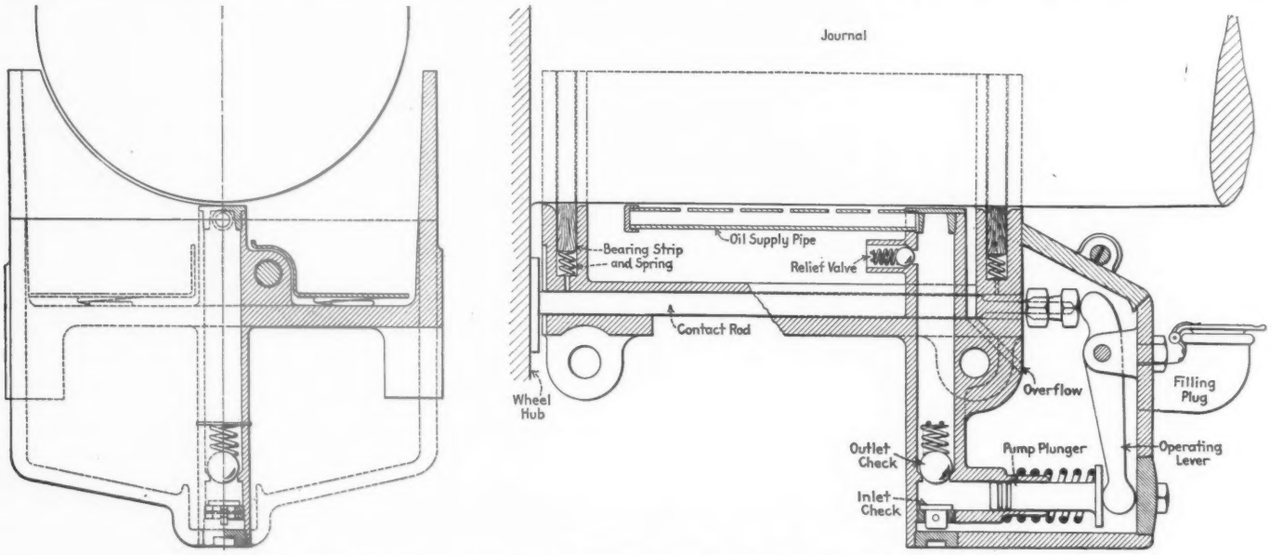
Hot water is used because it cuts the grease or frost from the rail more readily than cold water and is more conveniently taken from the boiler than from the tank. The patent, however, covers the taking of water from the boiler, injector or tank. In actual practice, the water consumption is about 85 gals. per hour, this being in the most severe service where the grade is continuous and curves numerous.

In such service the rail washers back of the rear drivers would be in operation practically all the time, washing sand from the rail, and the washers in front of the engine truck would be in operation when approaching and on curves. When using 85 gals. of water per hour, the coal consumption is about 118 lb., but in ordinary service 10 per cent of this amount is said to be sufficient. The comparatively slight cost of additional coal is felt to be unimportant in consideration of the greater tonnage that can be handled and the saving in flange and rail wear.

A Positive Mechanical Journal Lubricator

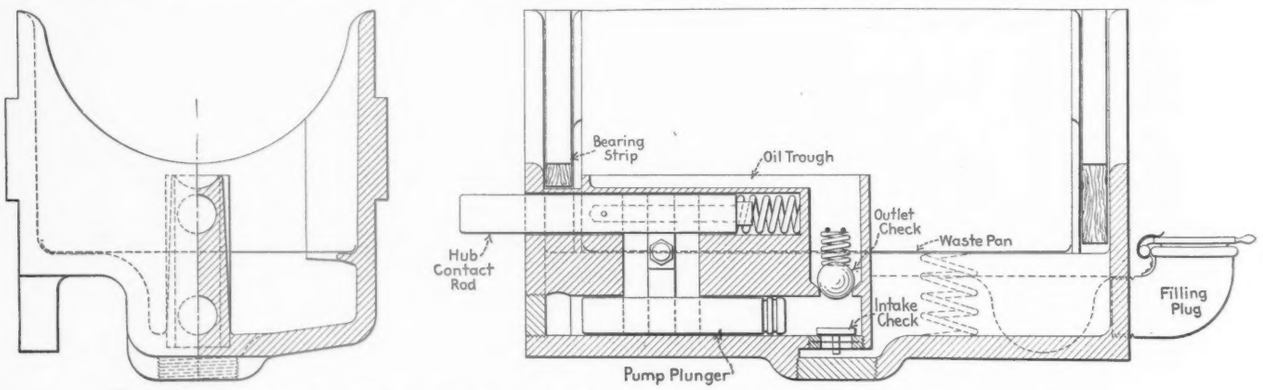
OWING to increased journal loads, speed requirements and extreme temperature variations in some parts of the country, present methods of lubricating the journals of railway equipment sometimes prove more or less inadequate. It is generally conceded that they have not kept pace with other improvements in equipment design. The amount of oil fed to high duty journals by capillary attraction through waste is insufficient and the direct results are costly hot boxes, delays and repairs to equipment. Contrary to the usual experience with car journals, locomotive driving journals lubricated with hard grease seldom become hot (at least hot enough to cut or score). This is because main bearings receive the personal attention of enginemen, and hard grease lubricates at a high temperature. The trouble is that hard grease does not begin to lubricate effectively until the journals become warm, and there is excessive friction.

The result of lubricating journal bearings with too light oil or too heavy grease is unnecessary friction, power loss, rapid wear of journals and bearings and consequent deterioration of other moving parts. Important economies in labor, material and reduced equipment delays would immediately result from delivering oil of a proper consistency (from a lubrication standpoint and not from a standpoint of its ability to feed through waste) to the journals. This oil should be delivered at all times and in a predetermined quantity regardless of atmospheric conditions by positive, reliable, mechanical means.



Lubricator Arrangement as Applied to the Journals of Main Driving Wheels

Lubricators designed to accomplish these results have been developed by the Hennessy Lubricator Company, New York, being made in four styles for use with locomotive trailer, driver and truck wheels; also car wheels. Advantages claimed for these lubricators are that they are cheap, fool proof, have few parts and are easily applied, displacing the regular cellars without change or addition to bearings, journals or boxes. The lubricators are packed with waste in the regular manner and can be applied in roundhouses by regular forces. Pumping action is obtained from lateral wheel movement which is positive and regular. The waste



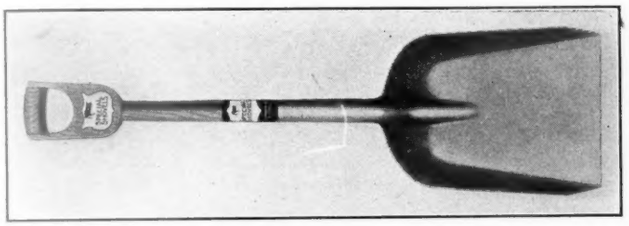
Cross Section Showing Operation of Hennessy Engine Truck Journal Lubricator

is kept in contact with the journals by means of loose plates and springs and oil, being pumped up through to the journals, prevents the waste from glazing. The waste, in addition to distributing oil over the faces of the journals, is also a safety feature in the event of the pump becoming inoperative for any reason. Being always saturated with oil, the waste will continue to lubricate the journals, heating gradually and finally smoking, if a hot box develops.

Tests of Hennessy lubricators on lead trucks have demonstrated that about five times the ordinary mileage is made with a given quantity of oil. While it is recommended that the lubricators be removed for inspection at intervals of about 90 days, some have been in service on the Norfolk & Western as long as 11 months without being taken down for any purpose. The only attention required is the filling or supplying of oil to the cellars about once a week, dependent upon the class of service. It is stated that oil of the consistency of vaseline can be pumped through the lubricator if necessary.

Lightweight Shovel of Sturdy Construction

RECENT improvements in shovel construction have been combined in a lightweight, rugged shovel made by the Conneaut Shovel Company, Conneaut, Ohio. It has long been the policy of this company to make special purpose shovels, and this new tool is made in two types and various sizes for molders and locomotive firemen. In both cases maximum wear and minimum weight are desired, and to serve this double purpose the shovel proper is made of molybdenum alloy steel. The steel scoop is rigidly fastened to a well-proportioned handle made of selected stock, the weights of the two shovels being made approximately 4 lb. and 5 lb., respectively. The hard service that a shovel must stand at the hands of molders and locomotive firemen is well understood and it is stated that severe tests have demonstrated the ability of the new Conneaut shovels to withstand any usage within reason. Any standard form of handle may be provided to suit the individual preferences of users.



Conneaut Special Firemen's Shovel Made of Molybdenum Steel

Ease of Operation Features New Coach Seat

ONE of the special features of a coach seat recently developed by the Scarritt Car Seat and Manufacturing Company, St. Louis, Mo., is freedom from jamming and ease of operation. This is secured by carrying the operating mechanism on four rollers, two on each side, operating in channels in the side plates, as shown in Fig. 1. The double automatic foot rest is designed to afford ample clearance for luggage beneath the seat, and, although it is mechanically operated, becomes inoperative when obstructed and allows the back to be reversed freely without injury to the seat mechanism or the obstructing baggage. The aisle arm is made of steel and can be enameled in any desired color and fitted with a wooden arm rest to match the finish of the car interior. The arm rest is firmly attached in place.

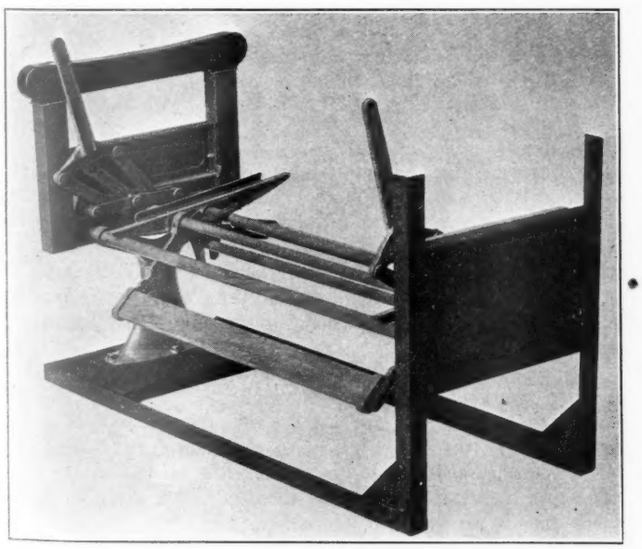


Fig. 1—View of Coach Seat Operating Mechanism

The seat can be equipped with any type of back cushion with or without a headroll. Fig. 2 shows the new type of back cushion with the Scarritt invisible headroll designed to afford maximum comfort to the passengers. The plush is applied without stitching and therefore can be renewed at a nominal labor cost, the elimination of all gimp and seams making this a most sanitary type of cushion. The seat cushion is of the full spring type with flexible edges and is designed to meet the most severe service conditions. The hand-stitched upper edge of the curled hair assures maximum life from the plush or other covering material. This seat was designed for first-class coaches and conforms to modern ideas of maximum comfort and durability in car equipment.

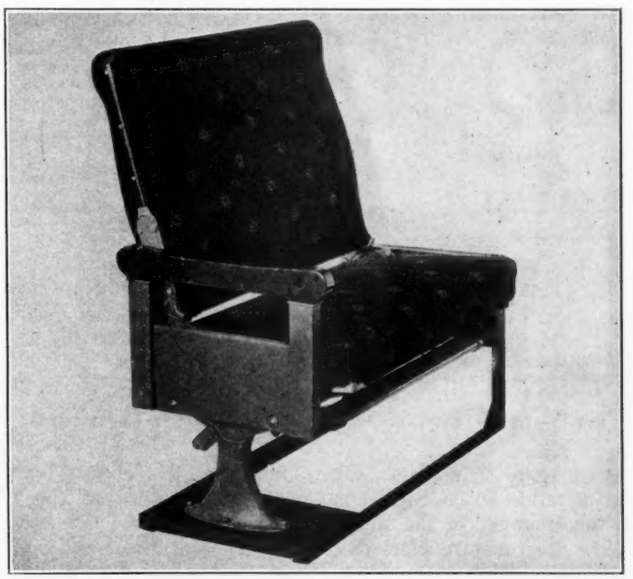


Fig. 2—Scarritt Coach Seat with Parts Assembled

Automatic Exhaust Pipe and Blower Valve

ON page 358 of the June, 1920, *Railway Mechanical Engineer* there appeared a description of an exhaust pipe invented by J. E. Osmer, superintendent of motive power of the Ann Arbor at Owosso, Mich. Recent improvements, made in this exhaust pipe, have demonstrated their value on the Detroit & Mackinac and the Ann Arbor and are protected by patents pending. The illustration (Fig. 1) shows the exhaust pipe as adapted to Mallet engines. It will be noted that both passages are equipped with automatic acting valves, which open in response to fluid pressure. The source of the supply may be from the steam pipes to either the high or low pressure cylinders, as may be selected.

When the engineer opens the throttle, the two valves are

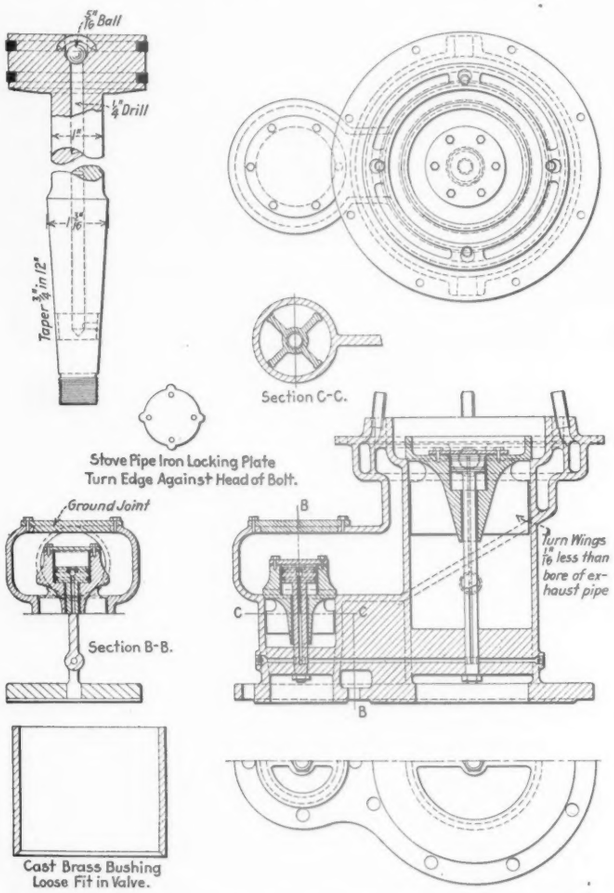


Fig. 1—Osmer Exhaust Pipe Adapted to Mallet Locomotive

raised from their seats. When the throttle is closed, both valves return to their seats, but not suddenly, as a ball check is incorporated in the steam passages leading to the space below the pressure plate so that a period of about one and one-half seconds is required for the valve to take its seat. The larger valve, around which all steam is exhausted into the stack when the locomotive is operating compound, is so constructed as to cause the discharge of exhaust steam in the form of a ring which completely fills the stack, thereby creating a more intense draft than can be obtained with the usual types of exhaust tips.

The steel balls are incorporated also to perform an additional function. When the throttle is closed, permitting the locomotive to coast down a grade without the use of steam, drifting valve or vacuum relief valves are not needed. The valve may raise and lower in response to the amount of air drawn in through the cylinder cocks, and will close on the seat gently.

One important object of this automatic exhaust pipe is to prevent drawing gases and cinders from the smoke box into the cylinders, which not only destroys lubrication, but is severe on cylinder and piston rod packing, necessitating repairs and renewals. The device also tends to prevent the breaking of shoes and wedges, rod brasses, shearing of rod bolts, loose guide bolt nuts, and the pounding of either the high pressure or low pressure engines when descending a grade with the locomotive throttle entirely closed. In the entire construction careful attention was given to eliminating back pressure as much as possible, and at the same time increasing efficiency by exhausting steam in the form of a ring.

New Design of Blower Pipe

The Osmer exhaust pipe applied to a simple engine is shown in Fig. 2 together with a combination automatic and

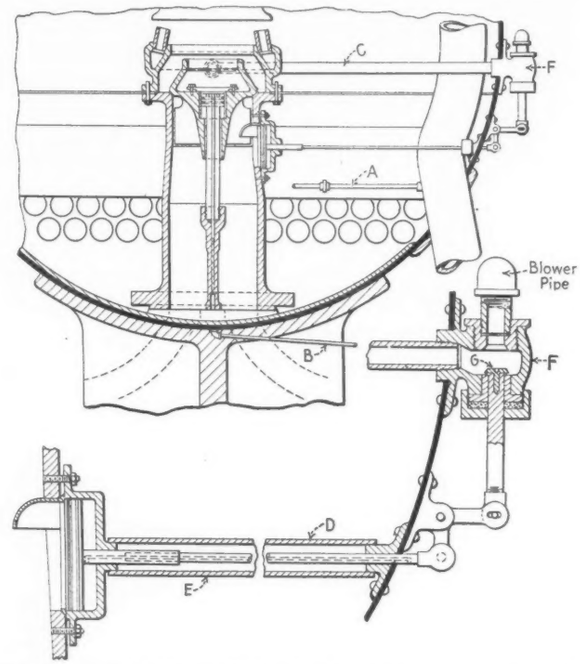


Fig. 2—Automatic Exhaust Pipe and Blower Valve as Applied to Simple Locomotive

hand blower valve *F* which may be applied to an engine equipped with any kind of an exhaust pipe. As shown, the blower may be operated as usual from the cab, or by rod and bell crank connection to a miniature cylinder attached to the exhaust pipe. This cylinder contains a piston that responds to the pressure within the exhaust pipe and automatically shuts off the blower valve whenever the engine is exhausting steam.

Assuming that the blower valve on the boiler head is open, pressure would be delivered through the pipe and passed downward on valve *G*, forcing it from its seat and causing steam to pass through pipe *C* to the nozzle tip, and jets. When the engine is working, steam pressure within the exhaust pipe moves the piston to the right, and automatically closes the blower valve *G* against its seat.

On suburban engines, firemen will regulate the valve on the boiler head to supply a jet of steam of sufficient force to carry off the smoke from the stack, and the moment the engineer closes the throttle, boiler pressure within the blower pipe will force the valve in the automatic valve from its seat

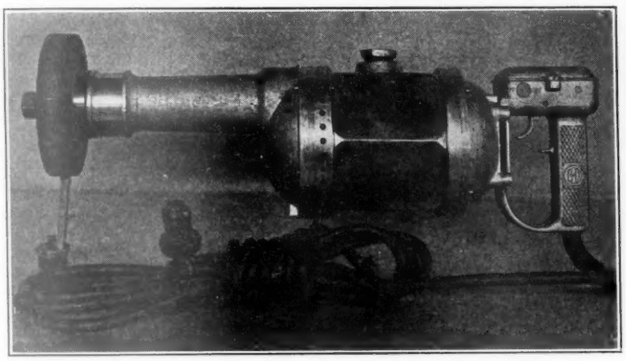
and automatically apply the blower. On switch engines in districts where the smoke ordinance is severe, the automatic blower responds instantly to the closing of the throttle valve by the engineer.

Pipe *D* (Fig. 2) eliminates drawing dust particles into the stuffing box of the cylinder. Pipe *B* is a fluid pressure pipe, connected to the steam chest for actuating the exhaust pipe valve but pipe *A* is a preferable design, being tapped into the steam pipe with no outside piping. This is an advantage.

When it becomes necessary to repair or reface the valve and seat in the automatic blower valve, the union in the blower pipe immediately back of the automatic blower valve *F* is detached, and the brass bushing which forms the seat unscrewed. By the use of a ¼ in. bolt, valve *G* may be withdrawn from the stem, and after being faced, replaced without difficulty. The time and expense involved is small.

Portable Electric Grinder With Pistol Grip

THE Black & Decker Manufacturing Company, Towson Heights, Baltimore, Md., has placed on the market recently a portable electric grinder equipped with a pistol grip and trigger switch. This arrangement adds to the convenience of operating the grinder which embodies most of the features included in standard Black & Decker drills. The operator has entire control over the grinder at all times and it is unnecessary to shift either hand to start or stop it.



Black & Decker Portable Electric Grinder Provided With Pistol Grip

While this grinder is essentially a portable machine it is supplied complete with an easily detachable base and adjustable tool rest so that it can be used with equal facility as a bench grinder. Besides the base, the equipment also includes two 5-in. by 1-in. grinding wheels (one fine and one coarse), a wire brush wheel and a rag buffing wheel. With these attachments the machine can be used for grinding, cleaning, buffing or miscellaneous polishing. Valuable features included in the grinder are grease lubrication throughout, forced air cooling, chrome nickel steel gears and shafts and aluminum alloy housing. The entire mechanism is protected from dust and other foreign matter. Owing to this form of construction the grinder is light and easy to handle. It may be operated on either direct or alternating currents at will, a ½-hp. motor being used operating at a speed of 3,200 r.p.m. The total weight when equipped with a 5-in. by 1-in. wheel is 21 lb.

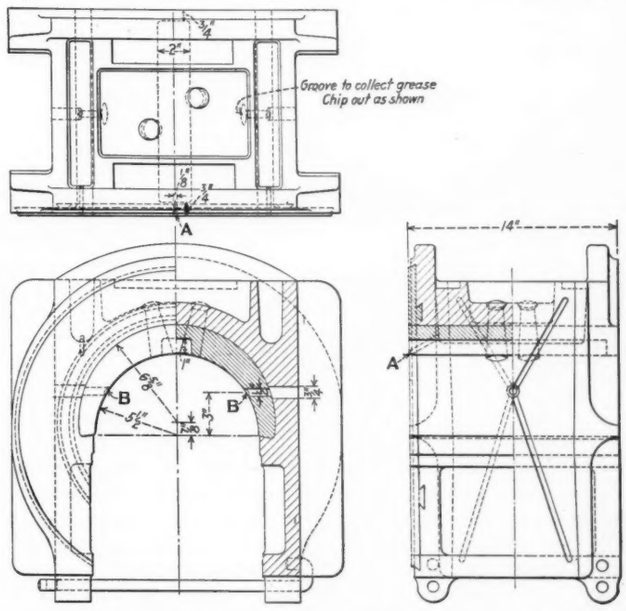
Driving Box Grease Groove Arrangement

ON locomotive driving boxes having grease pockets located in the crown brasses on either side of the vertical center line, it frequently has been found necessary to bore out the crown and refit the brass to prevent the box from pounding. The maximum wear in the crown brass occurs on either side of the vertical center line and the top of the crown shows very slight wear.

A test has recently been completed using driving boxes with a grease groove arrangement patented by L. P. Ligon, master mechanic, Norfolk & Western, Roanoke, Va. As illustrated, the crown brass has a grease cavity in the top of the crown extending practically the full length of the bearing and approximately two inches wide. On the crown brass with a properly proportioned cavity it was found that as the brass wore it continued to fit the axle closely. The top portion, being cut away, allowed uniform vertical wear at the sides and top and pounding did not develop.

The cavity in the top of the crown wipes the surplus oil and grease from the axle and acts as a reservoir. To take full advantage of this reservoir, a slot *A* is cut through the crown from the grease cavity to the face next to the hub liner so that the grease can flow through and lubricate the hub liner. The location of this slot is such that the grease is applied to the hub liner at its smallest diameter next to the axle, and flows out over the entire face. This principle is also extended and holes *B* are drilled through the crown brass to the shoe and wedge faces through which the grease flows lubricating these surfaces.

After being in service 15 months the boxes tested were removed and examined. Very little wear had occurred and the fit of the crown brass and the axle was found in good condition. No lubrication was applied to these surfaces except that through the cavity in the crown brass. It was shown conclusively by the test that crown brasses with grease cavities in the tops of the crowns not only do not pound but provide ample lubrication for hub liners as well as shoe and wedge faces through holes or slots to these surfaces.



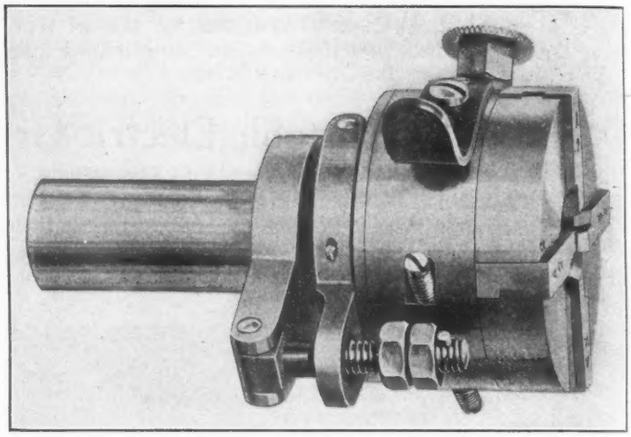
Grease Grooves Arranged to Lubricate Hub Face and Shoe and Wedge Ways

Self-Opening and Adjustable Die Heads

A NEW self-opening and adjustable die head, style DS, has been developed by the Geometric Tool Company, New Haven, Conn. This head was designed primarily for use on Brown & Sharpe automatic screw machines, but may be used on other automatics, rendering unnecessary any arrangement to reverse the spindle and back the die head off the threaded work. The head is of simple, compact construction and works independently of the turret feed, floating to suit the thread being cut. This prevents stripping and shaving the threads and makes the usual close camming of the machine unnecessary.

A lever trip is provided which reduces the force of tripping the die head and therefore lightens the reaction on the threads being cut. Buffer springs allow the head to yield slightly when the chasers come in contact with the work, insuring a smooth thread. Two check nuts on the side of the head provide easy adjustment of the point of tripping. A spring closing attachment eliminates as far as possible shock and wear, being located in a convenient position to strike a stop on the machine which automatically closes the die head when the turret revolves.

The chasers are of sturdy construction, having long bearings in the die head skeleton and are supported by hardened keys which prevent tilting and consequent cutting of taper threads. Four chasers are provided in each die head and the shanks are arranged to fit the particular size of machine on which they are used. These die heads are made in three sizes and have a capacity to cut threads from 1/16 in. to ¾ in. in diameter with pitches varying from 18 or finer to 10.



Geometric Self-Opening Die Head, Style D. S.

Franklin Precision Power Reverse Gear

UNUSUAL and interesting tests of the new Franklin Precision power reverse gear manufactured by the Franklin Railway Supply Company, Inc., New York, were made recently at Franklin, Pa. The object was to put the gear through tests that would duplicate locomotive service as nearly as possible and to subject it to conditions more severe than would occur on the locomotive itself. The specific purposes of the tests was to determine whether the piston would absorb valve motion shocks without moving, whether the gear would remain where set without creeping, whether the cut-off could be readily adjusted under load, whether the cut-off indicator and gear would work in synchronism, whether shock and stresses would be eliminated from the control going to the cab and whether the gear would automatically and instantly resist movement if an unbalanced load was suddenly applied.

To determine these points, special testing apparatus shown in Fig. 2 was constructed. The gear was secured to the frame in the same way in which it is applied to a locomotive. Application of the cab control wheel and operating rod was made in the same relative position as actual service requires and the cut-off indicator set at its proper relation to the gear. Compressed air at a pressure of 105 lb. per square inch was applied to the cylinder. A set of gages was attached to the cylinder compartment for pressure reading, bleed cocks being installed at each gage.

To subject the reverse gear to stresses similar to those received from the valve gear when a locomotive is running, an extended rod was attached to the gear piston rod. This rod passed through an adjustable friction clutch by means of which varying and very heavy resistances could be applied. To the friction clutch was attached a connecting rod which was operated by an eccentric with one inch travel, driven by an electric motor. The eccentric served to reciprocate the clutch on the extended piston rod, subjecting the gear to shock and reversal of stresses equaling those occurring in actual service.

Frictional resistance between the adjustable clutch and extended piston rod was obtained by tightening the clutch. These frictional resistances were calibrated by hanging known weights on a cable which passed over a pulley and was hooked on the extended piston rod. When the friction of the clutch stopped the weight from moving, the frictional resistance equalled the load on the cable. This weight ar-

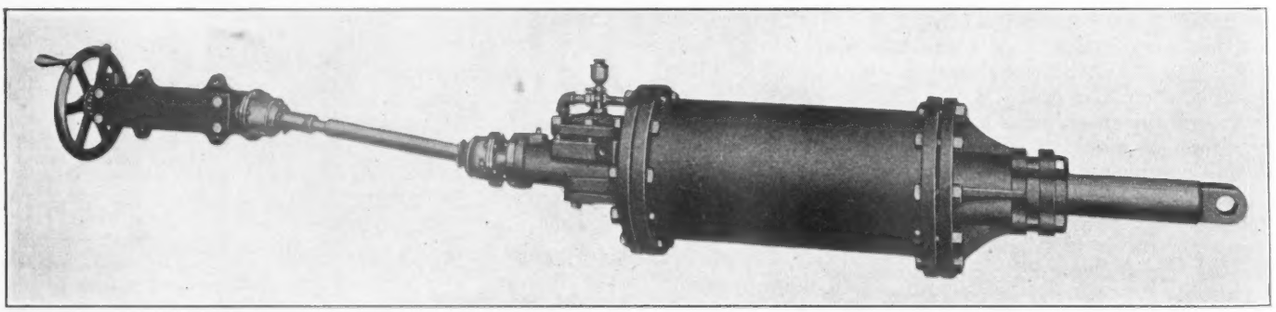


Fig. 1—Gear Assembled as Applied to the Locomotive

rangement was used to establish a known frictional resistance.

Two conditions were considered, the first where the force acting on the gear piston was the same in both directions, the second an unbalanced force acting in one direction only. In the first case the desired frictional resistance between the clutch and rod was obtained as outlined above, and the cable and weights were disconnected from the rod. The motor was then started and the clutch forced to travel back and forth on the piston rod 320 times per minute. Observations were taken on ten separate tests, each test being run without a stop for 30 minutes.

To duplicate the condition of an unbalanced force acting on the gear in one direction only, the frictional resistance of the clutch was first set to equal the weight hung on the rod and the weight not disconnected.

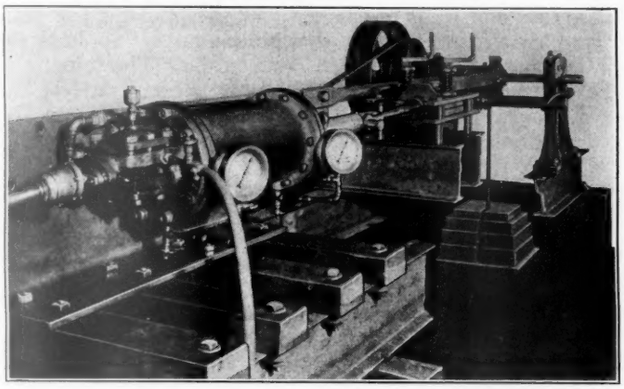


Fig. 2—Gear With Rod and Clutch Attached for Test

In starting these tests, observations were taken with no load on the gear in order to establish the position of the cab indicator relative to the actual point of cut-off. Moving the indicator from corner to corner and setting to any desired cut-off the relative positions of the indicator and piston checked in every case within 1/32 in.

Seven separate running tests were made with the clutch operating against the gear in each direction. The first test was run with 500 lb. frictional resistance between clutch and piston rod and the resistance was increased 500 lb. for each test until a load of 3,500 lb. was reached. With the motor reciprocating the clutch 320 times per minute, there was absolutely no movement of the piston. The gear was moved from corner to corner slowly or as rapidly as desired and the cut-off always checked with the position shown by the cab indicator. While under load, the force required to adjust the cut-off was so small that the operating rod could be rotated by hand without using the cab control wheel. The gear absorbed all shocks, no vibration or stresses being transmitted to the cab control wheel or indicator.

To demonstrate the operation in case of leaks, the pressure in the cylinder was bled down approximately 15 per cent. Under these conditions the piston moved .005 in. each way under load. When the leakage cock was closed the pressure automatically rose and stopped all movement of the piston.

To determine the effect of an unbalanced load in one direction only, the clutch was set for 2,000 lb. and weights left attached, the clutch and weight equaling 4,000 lb. one way and zero the other. Under these conditions the gear immediately set up the differential pressure in the cylinder required to absorb the shocks. There was no movement of the piston and bleeding of each cylinder compartment by hand had no effect.

To further unbalance the load the clutch pressure was increased to 2,500 lb., making a load of 5,000 lb. acting on the gear in one direction only. No movement of the gear was perceptible, the cut-off being held as rigidly as before.

Description of Gear

This power reverse gear, as its name implies, is designed for precise adjustment of cut-off. It consists of a 10 in. by 18 in. cylinder with all parts enclosed. It has ample strength for the heaviest work. The operating valve is attached to the rear end of the cylinder and is controlled by a hand wheel in the cab. This wheel is provided with an indicator showing the point of cut-off and is connected to the gear by an operating rod. This wheel and rod are relieved of all stresses or shocks in the functioning of the gear.

No crosshead or guide is used with this gear, the thrust being taken through the piston. Levers and rods have been eliminated and there are no pins or bushings to wear and affect the accuracy of cut-off. No adjustments are provided as none are required. Wearing parts have been reduced to the minimum. Steam can be used as a medium for operating the gear in emergencies.

The results of the tests described above show that the gear provides extremely accurate adjustment of cut-off and freedom from creeping. Pressure is automatically set up to resist sudden unbalanced forces and maintain stability of adjustment. All shocks from the valve gear are absorbed by the air in the gear cylinder. The design gives a low air consumption and provides adjustment of cut-off with minimum physical effort. When air is cut off, the gear remains positioned corresponding to the last adjustment and cannot be changed until air or steam is again used.

Long Distance Recording Thermometers

STURDINESS of design is a feature of the new thermometer made by the Brown Instrument Company, Philadelphia, Pa., to record temperatures at a distance. The thermometer can be furnished with tubing up to 150 ft. in length if required. Shorter lengths, however, are to be desired since the instrument is proportionately sensitive. The capillary tubing is protected by a reinforced flexible drawn tubing which can be stepped on without injury.

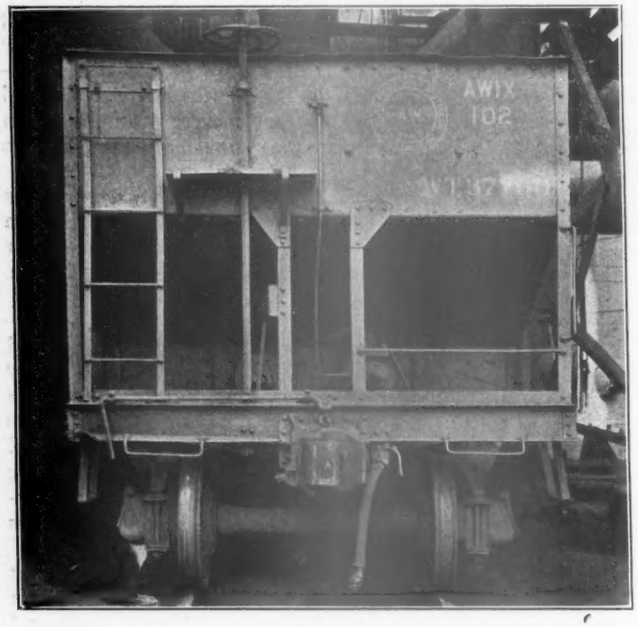
Bulbs have been developed to meet every requirement and are made of drawn copper tubing with a heavy coating of nickel. This nickel coating materially increases the resistance to oxidation.

Other important features are included in the design of the thermometer itself. By turning a knob, the pen can be set at the exact temperature without the necessity of bending the pen arm with the fingers. Another slight adjustment makes the pen bear more heavily or lightly on the paper. The pointer, setting device and actuating spring are assembled in a compact, reliable unit. A patented method for calibrating the instrument is supplied. The pen arm lifts when the door is open and is replaced automatically on the paper when the door is closed. A Seth Thomas clock is used to provide the clock movement. Another feature is the inverted pen which prevents ink from running down and corroding the pen arm. The entire mechanism is enclosed in a dust and moisture proof case.

One of the uses for which this recording thermometer should prove particularly valuable is the measuring and recording of superheated steam temperatures in stationary power plants. The accurate control of superheated steam temperature is essential to efficient boiler operation and this control is only possible by use of temperature recorders.

Safety Hand Brake Stands Severe Tests

A NEW design of safety hand brake, made by the Minich Railway Appliance Corporation, Philadelphia, Pa., has been tested recently under severe service conditions and reported on favorably by the Interstate Commerce Commission. The brake consists of a vertical shaft, similar to those in common use, and attached as usual to the end of the car. The bottom of the shaft, however, is supported by a special cage casting, and is threaded to take a nut which is guided by slots in the cage. The nut moves vertically up and down, depending on which way the staff is revolved. On opposite sides of the nut are lugs forming trunnions by which a U-shaped lever is operated. The usual brake chain, or air brake lever in the case of hopper cars is replaced by a connecting rod. Round lugs on opposite sides of the cage serve as a fulcrum for the U-lever so that when the staff is revolved and the nut raised, the lever revolves on these lugs and tends to change from an approximately horizontal to a vertical position, thus pulling up and applying the brakes through the rigging in common use. The fulcrum of the U-lever changes so that the power is comparatively low at the beginning, permitting the slack to be taken up quickly, but resulting in an increase of leverage and power towards the end of the application. No pawl is necessary to hold the brakes applied, since they can be released only by turning the staff in the opposite direction.



Hopper Car Provided with Minich Safety Hand Brake Equipment

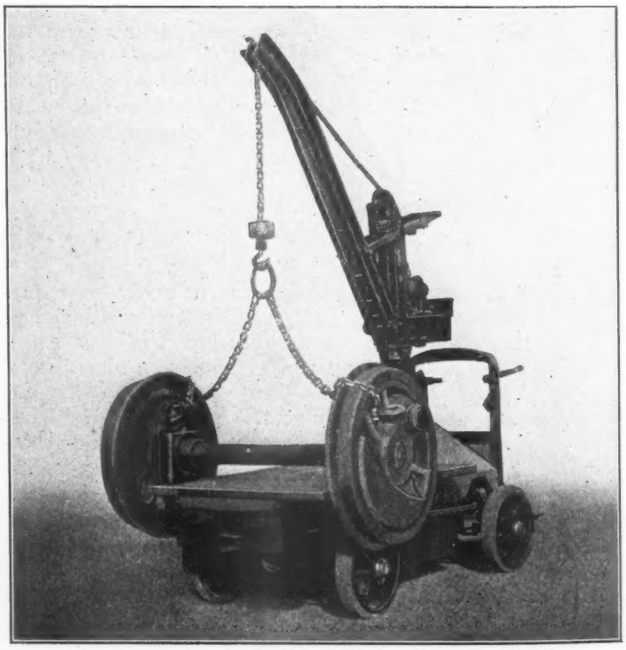
It is maintained that this brake is an important safety device, being more efficient, inexpensive and easier to operate than the familiar ratchet and pawl type. The brake holds where applied and is not released partly to allow a pawl to engage, consequently all the energy is maintained and not lost when most needed. The brake is said to be three times as powerful as an ordinary brake and this without the use of a brake stick. Ratchet, pawl and brake chain are eliminated. It is stated that cars can be controlled accurately and easily on down grades, accidents being prevented by eliminating danger of sudden releases. All stress on the staff is vertical, therefore the parts will not be frequently bent and forced out of alinement. Owing to the use of few parts and a short, light staff, it is easy to install and maintain the brake.

Storage Battery Truck Equipped with Crane

STORAGE battery trucks have demonstrated their ability as labor saving devices in railroad shops and storerooms and many of these trucks are now equipped with devices to facilitate loading and unloading. To eliminate manual labor as much as possible the Yale & Towne Mfg. Co., Stamford, Conn., has developed the crane-equipped truck, illustrated, with a total load carrying capacity of 4,000 lb. It can be run at speeds up to 6 miles an hour loaded, negotiating grades up to 12 per cent, and running over any road that presents a reasonably smooth surface. It does not need to be jockeyed into position before lifting the load, which may be picked up by the crane from either side of the truck or from the end, since both the boom and load chain may be raised simultaneously, thus lengthening or shortening the out-reach of the boom as required. The crane has a total capacity of 1,600 lb. at the maximum out-reach position of 69½ in. from the center line of the mast. This load capacity increases as the out-reach decreases until at a distance of 24 in. the crane will pick up 1,900 lb.

The truck illustrated has been subjected to severe tests, it is said, with satisfactory results, and experiments are now being carried on at the plant with the idea of equipping the truck with an electro-magnet and dump body. The dump body will be especially valuable for use in picking up and handling quickly scrap metal. The assembled wheels and axles, shown in the illustration, weigh approximately 1,800 lb. and it would require considerable effort on the part of two or possibly four men to roll these wheels onto the truck without the crane.

The truck is equipped with a storage battery operating both truck driving mechanism and crane mechanism. The weight of the truck complete ready for shipment is 3,200 lb.



Yale & Towne Crane-Equipped Truck Carrying Small Driving Wheels

Railway Mechanical Engineer

(*Formerly the* RAILWAY AGE GAZETTE, MECHANICAL EDITION *with which the* AMERICAN ENGINEER *was incorporated*)

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WE GUARANTEE, that of this issue 8,800 copies were printed; that of these 8,800 copies 7,719 were mailed to regular paid subscribers; 8 were provided for counter and news company sales; 251 were mailed to advertisers; 32 were mailed to employees and correspondents and 790 were provided for new subscriptions, samples, copies lost in the mail and office use; that the total copies printed this year to date were 67,500, an average of 9,643 copies a week.

The *Railway Mechanical Engineer* is a member of the Associated Business Papers (A. B. P.) and the Audit Bureau of Circulations (A. B. C.)

A fire at the roundhouse of the Boston & Maine, Portsmouth, N. H., on June 20, damaged the building and several locomotives at a total estimated loss of $150,000.

The Baltimore & Ohio has consolidated the Ohio river and the Wheeling divisions, making Wheeling, W. Va., the headquarters and discontinuing the offices at Parkersburg. On the Indiana division, Seymour, Ind., has been abandoned as a freight terminal and North Vernon is to be the terminal instead.

The Mechanical Division of the American Railway Association has issued a supplement to the 1920 Rules of Interchange, prepared by the Arbitration Committee. This supplement includes corrections to the rules, several additional interpretations rendered by the committee, and a few changes which have been made to clarify the rules.

The Chicago Chapter of the American Society for Steel Treating has elected the following officers: Chairman, H. M. Wood, Ingalls-Shepard division, Wyman Gordon Company, Harvey, Ill.; vice-chairman, T. A. Lovegren, Standard Forging Company, Indiana Harbor, Ind.; secretary-treasurer, Harry Blumberg, Illinois Steel Company.

The Missouri-Illinois Railroad on June 1 opened its entire line for business. The line of this company, which is the successor of the Illinois Southern, extends from Salem, Ill., southwest to Kellogg, on the Mississippi River, and from St. Genevieve, Mo., southwest to Bismarck, a total distance of 127 miles, with a branch from Collins, Ill., south, to Chester, 11 miles.

The new classification of railroad employees and rules for reporting their number and compensation announced some time ago by the Railroad Labor Board has been completed and issued in book form to the carriers. The employees are divided into approximately 148 classes, which in turn have been subdivided so that there are approximately 500 distinctive classes created.

Honorary Degrees

At the commencement exercises at Williams College, Williamstown, Mass., on June 20, the honorary degree of doctor of laws was conferred on Edgar E. Clark, chairman of the Interstate Commerce Commission.

At the commencement exercises at Tufts College, Medford, Mass., on June 20, the honorary degree of master of arts was conferred on Samuel O. Dunn, editor of the *Railway Age*.

Mechanical Division Scholarships

Three vacancies occurred in June, 1921, in the scholarships awarded to sons of railroad men or others with experience in the mechanical department and administered through the Mechanical Division of the American Railway Association. Two of the vacancies are in the scholarships at Stevens Institute of Technology and the third is one of the Joseph T. Ryerson & Son's scholarships which provides for a four-year course at universities elected by the American Railway Association. Application for these scholarships can be made through V. R. Hawthorne, secretary of the Mechanical Division.

Locomotives

THE ERIE RAILROAD has bought from the Surplus Property Division of the War Department 45 of the Decapod locomotives originally built for the Russian government. These constitute the remainder of the Decapods held by the government.

Freight Cars

THE PITTSBURGH & WEST VIRGINIA has ordered 300 hopper car bodies of 55 tons' capacity from the Cambria Steel Company.

THE ERIE RAILROAD will have repairs to 1,000 box cars of 40 tons capacity made at the Hammond shops of the Standard Steel Car Company.

The GREAT NORTHERN has ordered 500 refrigerator cars from the General American Car Company. These cars are to have wooden underframes.

THE MINNEAPOLIS, ST. PAUL & SAULT STE. MARIE has awarded a contract to the American Car & Foundry Company, for the repair of 500 box cars.

MITSUI & Co., New York, has ordered 40 air dump cars for the South Manchurian Railway from the Kilbourne & Jacobs Manufacturing Company. These cars are to be of 20 cu. yd. capacity.

THE UNION PACIFIC has given an order to the Pacific Car & Foundry Company for repairs to 1,000 box cars. The work is to be carried out at the Portland plant of the Pacific Car & Foundry Company.

Shop Construction

THE ILLINOIS CENTRAL has awarded a contract for an extension to its roundhouse at Paducah, Ky., to the Ellington-Miller Company, Chicago, at a cost of approximately $15,000. This company has also awarded a contract for the construction of additions to its roundhouse at Waterloo, Iowa, to W. J. Zitterall, Webster City, Iowa.

THE LOUISVILLE & NASHVILLE has awarded contracts to Joseph E. Nelson & Sons, Chicago, in connection with improvements to

its terminal at Hazard, Ky., for the construction of a roundhouse, machine shop, oil storage building, car department building, storage and office building, lavatory building, and an engineers' locker and register building. The total cost of the project is approximately $180,000.

A. R. A. Mechanical Division Meeting Postponed Indefinitely

The postponed meeting of the Mechanical Division, American Railway Association, which was to have been held at the Blackstone Hotel, Chicago, on Wednesday and Thursday, June 29 and 30, has again been postponed as announced in a circular issued by the Mechanical Division on June 21. In view of the uncertainty as to conditions for the next few weeks no date has been set for the postponed meeting.

MEETINGS AND CONVENTIONS

The *Chief Interchange Car Inspectors' and Car Foremen's Association* convention for this year has been postponed.

The *American Railway Tool Foremen's Association* convention which was to have been held at the Hotel Sherman, Chicago, on August 9, 10 and 11, has been postponed.

The *International Railroad Master Blacksmiths' Association* convention which was to have been held at the Hotel Sherman, Chicago, on August 16, 17 and 18, has been postponed.

The *International Railway General Foremen's Association* has decided to cancel its 1921 convention which was to have been held September 12, 13, 14 and 15 at the Hotel Sherman, Chicago, owing to the financial stress and serious business conditions.

The following list gives names of secretaries, dates of next or regular meetings and places of meeting of mechanical associations and railroad clubs:

Air-Brake Association.—F. M. Nellis, Room 3014, 165 Broadway, New York City.

American Railway Association, Division V—Mechanical.—V. R. Hawthorne, 431 South Dearborn St., Chicago.
Division V—Equipment Painting Division.—V. R. Hawthorne, Chicago.

American Railway Association, Division VI—Purchases and Stores.—J. P. Murphy, N. Y. C., Collinwood, Ohio.

American Railroad Master Tinners', Coppersmiths' and Pipefitters' Association.—C. Borcherdt, 202 North Hamlin Ave., Chicago. Convention September 12-14, Hotel Sherman, Chicago, Ill.

American Railway Tool Foremen's Association.—R. D. Fletcher, 1145 E. Marquette Road, Chicago.

American Society for Testing Materials.—C. L. Warwick, University of Pennsylvania, Philadelphia, Pa.

American Society of Mechanical Engineers.—Calvin W. Rice, 29 W. Thirty-ninth St., New York.

American Society for Steel Treating.—W. H. Eisenman, 4600 Prospect Ave., Cleveland, Ohio. Annual convention September 19-24, Indianapolis, Ind.

Association of Railway Electrical Engineers.—Joseph A. Andreucetti, C. & N. W., Room 411, C. & N. W. Station, Chicago, Ill.

Canadian Railway Club.—W. A. Booth, 131 Charron St., Montreal, Que. Meeting second Tuesday of each month except June, July and August, at Windsor Hotel, Montreal.

Car Foremen's Association of Chicago.—Aaron Kline, 626 N. Pine Ave., Chicago, Ill. Meeting second Monday in month, except June, July and August, New Morrison Hotel, Chicago, Ill.

Car Foremen's Association of St. Louis.—Thomas B. Koeneke, 604 Federal Reserve Bank Building, St. Louis, Mo. Meetings first Tuesday in month at the American Hotel Annex, St. Louis, Mo.

Central Railway Club.—H. D. Vought, 95 Liberty St., New York, N. Y.

Chief Interchange Car Inspectors and Car Foremen's Association.—W. P. Elliott, T. R. R. A. of St. Louis, East St. Louis, Ill.

Cincinnati Railway Club.—W. C. Cooder, Union Central Building, Cincinnati, Ohio. Meeting second Tuesday of February, May, September and November, at Hotel Sinton, Cincinnati.

Dixie Air Brake Club.—E. F. O'Connor, 10 West Grace St., Richmond, Va.

International Railroad Master Blacksmiths' Association.—W. J. Mayer, Michigan Central, 715 Clarke Ave., Detroit, Mich.

International Railway Fuel Association.—J. G. Crawford, 702 East Fifty-first St., Chicago, Ill.

International Railway General Foremen's Association.—William Hall, 1061 W. Wabasha Ave., Winona, Minn.

Master Boilermakers' Association.—Harry D. Vought, 95 Liberty St., New York, N. Y.

New England Railroad Club.—W. E. Cade, Jr., 683 Atlantic Ave., Boston, Mass. Meeting second Tuesday of each month, except June, July, August and September.

New York Railroad Club.—H. D. Vought, 95 Liberty St., New York, N. Y.

Niagara Frontier Car Men's Association.—George A. J. Hochgrebe, 623 Brisbane Building, Buffalo, N. Y.

Pacific Railway Club.—W. S. Wollner, 64 Pine St., San Francisco, Cal.

Railway Club of Pittsburgh.—J. D. Conway, 515 Grandview Ave., Pittsburgh, Pa.

St. Louis Railway Club.—B. W. Frauenthal, Union Station, St. Louis, Mo. Meeting second Friday of each month, except June, July and August.

Traveling Engineers' Association.—W. O. Thompson, 1177 East Ninety-eighth St., Cleveland, Ohio.

Western Railway Club.—Bruce V. Crandall, 14 E. Jackson Boulevard, Chicago. Meeting third Monday of each month, except June, July and August.

PERSONAL MENTION

GENERAL

C. M. Hoffman, superintendent of machinery of the Verde Tunnel & Smelter railroad, with headquarters at Clarkdale, Ariz., has been appointed superintendent motive power and machinery of the Los Angeles & Salt Lake, with headquarters at Los Angeles, Cal., succeeding D. P. Kellogg, who has resigned.

F. D. Wildrick, chief clerk to the mechanical superintendent of the New York Terminal Region of the Erie, has been appointed office manager of all offices in the mechanical department of the New York Terminal Region. Mr. Wildrick's headquarters will be at Jersey City, N. J.

MASTER MECHANICS AND ROAD FOREMEN OF ENGINES

J. Jones has been made locomotive foreman of the Canadian Pacific at MacTier, Ont., vice J. J. Dey, transferred.

F. T. Knight, locomotive foreman of the Canadian National Railways at Port Arthur, Ont., has been appointed locomotive foreman of the Grand Trunk Pacific at Sioux Lookout, Ont., succeeding W. H. Fletcher, transferred.

E. J. McSweeney, division master mechanic of the Baltimore & Ohio with headquarters at Washington, Ind., has been transferred to Garrett, Ind., succeeding W. F. Moran, resigned. C. M. Newman succeeds Mr. McSweeney.

C. C. Reynolds has been made road foreman of engines of the Santa Fe at Redondo Junction, Cal., succeeding F. A. Gibbs.

SHOP AND ENGINEHOUSE

Harry E. Wells has been made general foreman of the Atchison, Topeka & Santa Fe, at Marceline, Mo., succeeding J. Banker, retired.

PURCHASING AND STORES

Ernest O. Cook has been made storekeeper of the Santa Fe at Riverbank, Cal.

John E. Mahaney, whose appointment as superintendent of stores of the Chesapeake & Ohio was announced in the June issue of the *Railway Mechanical Engineer*, was born at St. Paul, Minn., December 23, 1879, and entered railway service in the stores department of the Minneapolis, St. Paul & Sault Ste. Marie at Minneapolis in 1895. In 1900 he went with the Eastern Minnesota (Great Northern) as general foreman. From 1903 to 1906 he served the Chicago, Rock Island & Pacific in a similar capacity. He then served the Southern Pacific as storekeeper, leaving that position in 1910 to become general storekeeper of the Oregon-Washington Railroad & Navigation Company. In 1913 he went with the Spokane, Portland & Seattle as general purchasing agent and general storekeeper. Two years later he became general storekeeper of the Norfolk Southern. During federal control Mr. Mahaney served the Procurement section, Railroad Administration, as supervisor of stores of the Northwestern region. On May 1, 1919, he returned to the Norfolk Southern as general storekeeper, which position he held at the time of his recent appointment.

OBITUARY

Robert Kennedy Reading, who served as superintendent of the Pennsylvania Railroad at Williamsport, Buffalo and Altoona, died very suddenly at Williamsport, Pa. Mr. Reading was for about 40 years in the employ of the Pennsylvania.

Portraits on Tickets.—The New York Central announces that buyers of commutation tickets, for use between New York City and certain points 50 miles or more from the city, are to be required to furnish a photograph, to be pasted on the ticket; this to prevent misuse of tickets, which has become common. On the Hudson division this order applies to Beacon and Poughkeepsie; on the Harlem division to Towners and Patterson, and on the River division to Newburgh.

SUPPLY TRADE NOTES

The Standard Pressed Steel Company has removed its headquarters from Philadelphia to Jenkintown, Pa.

The Canton Foundry & Machine Company, Canton, Ohio, has removed its New York City office from the Grand Central Palace to 45 West Eighteenth street.

The American Flexible Bolt Company removed its sales offices on June 1 from 50 Church street to the Liggett building, Forty-second street and Madison avenue, New York City.

The Steel Fabricating Corporation recently completed its new works and general offices at Michigan City, Ind., and has removed its executive headquarters from Harvey, Ill., to Michigan City.

The Canadian Locomotive Company, Ltd., Kingston, Ontario, is carrying out improvements at its shops, to include two additional pits to the erecting shop and the construction of a storage building 200 ft. by 75 ft.

Max Grant, manager of technical railway sales of the Glidden Company, Cleveland, Ohio, has left the service of that company to become manager of the railway paint department of the Acorn Refining Company, Cleveland.

The Dressel Manufacturing Corporation, New York, has established an office in the Railway Exchange, Chicago, under the supervision of De F. Lillis, who for many years was connected with the motive power department.

P. R. Letts has been appointed office manager of the industrial bearings division of the Hyatt Roller Bearing Company, New York, succeeding G. J. Traendly, who is now office manager of the General Motors Corporation, New York.

E. J. Floor has been appointed district sales manager of the Page Steel & Wire Company at 208 South La Salle street, Chicago, succeeding W. R. Bleecker, Jr., who has been transferred to the New York office of the company.

M. E. Lisle, assistant to the president of the Terminal Engineering Company, Inc., 17 West Forty-fourth street, New York City, has been elected vice-president and M. E. Peck, office manager, has been elected secretary and assistant treasurer.

The Combustion Engineering Corporation, 43 Broad street, New York, has removed its Philadelphia, Pa., branch office from 1112 Lincoln building to the tenth floor of the Finance building. This territory is under the management of W. C. Strips.

C. W. Cross has been appointed railroad representative of the Torchweld Equipment Company, Fulton and Carpenter streets, Chicago. Mr. Cross was until June 1, manager of western railroad sales for the Chicago Pneumatic Tool Company.

The Vacuum Oil Company, 61 Broadway, New York City, has opened new branch offices at Buffalo, N. Y., and Dallas, Tex. The Buffalo office will cover New York State west of the Hudson river and the Dallas office the states of Texas and Oklahoma.

The Geometric Tool Company, New Haven, Conn., manufacturers of screw thread cutting and tapping tools, have taken over the exclusive sale of high speed tapping devices, quick change chucks and collets and combination tapping devices equipped with quick change chucks, manufactured by the Charles L. Jarvis Company, Gildersleeve, Conn.

William Archie Kyte, sales manager and a member of the board of governors of the Foster Machine Company, died on May 24 at his home in Elkhart, Ind. Mr. Kyte was born at Middlebury, Ind., on March 1, 1878, and his association with the Foster Machine Company started in 1905. His death was caused by nervous exhaustion and heart trouble, after an illness dating from last January.

The Link-Belt Company, Chicago, has acquired all of the capital stock of the H. W. Caldwell & Son Company, Chicago, and Frank C. Caldwell has been elected a director of the Link-Belt Company. The Caldwell Company's plant will continue to operate under separate corporate existence, under its present name, and the plant management will remain substantially the same as heretofore.

Karl G. Roebling, president of John A. Roebling's Sons Company, Trenton, N. J., died at Springlake, N. J., on May 29, while playing golf. He was born at Trenton in 1873. Mr. Roebling was graduated from Lawrenceville school and from Princeton University in the class of 1894. He went with the Roebling company immediately after graduation and in 1918 was elected president of the company.

The Master Tool Company, 20 East St. Clair avenue, Cleveland, Ohio, has been organized under the laws of Ohio to manufacture a new line of pneumatic tools, and will specialize in the reclaiming of all types and makes of same. The officers of the company are: J. Nightingale, president; Charles F. Overly, vice-president and general manager; William Eckert, secretary-treasurer. C. F. Overly is manager of sales.

The Elliott Company, Jeannette, Pa., announces the following changes in its sales organization: R. H. Schmidt goes to the St. Louis district office, W. E. Widau to the Cleveland office, and R. S. Bellman to the Philadelphia district office. In addition to the Elliott Company's products, they will also handle those of the Lagonda Manufacturing Company, Springfield, Ohio, and the Liberty Manufacturing Company, Pittsburgh, Pa.

Alexis I. du Pont, secretary and director of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., died on May 30, at Wilmington after an illness of ten days. He was born in Wilmington in 1869, and graduated from Harvard in 1892. After graduation he took up work with the du Pont company, and had long been associated with the other members of his family in many of the large undertakings connected with their name.

Harry W. Torney, of Torney & Co., New York, was recently elected president of the Sharon Pressed Steel Company, with office at 66 Broadway, New York City. This company was recently reorganized. Arthur W. Swan is now general manager in charge of manufacture; he was formerly chief engineer and works manager of the Crucible Steel Company and its associates. J. G. White has been appointed district sales manager at Detroit, Mich. The company recently installed some new machinery at its plant, Sharon, Pa.

Charles A. Kothe has been appointed mechanical superintendent of the American Automatic Connector Company, Cleveland, Ohio, succeeding N. M. Barker, resigned. Mr. Kothe in 1900 entered the service of the Erie Railroad as a machinist and subsequently served in various positions at different places until 1913, when he was promoted to master mechanic at Marion, Ohio. He subsequently was transferred in the same capacity to Port Jervis, N. Y., and from 1919 served as general inspector at Youngstown, Ohio, until his recent appointment with the American Automatic Connector Company.

Colonel Washington A. Roebling, for many years vice-president of John A. Roebling's Sons Company, Trenton, N. J., has been elected president, to succeed his nephew, Karl G. Roebling. Colonel Roebling, who is 84 years old, was engaged with his father, John A. Roebling, in building the suspension bridge over the Allegheny river at Pittsburgh, and the Cincinnati and Covington suspension bridge. With his brother, Charles G. Roebling, he successfully carried out the work of completing the Brooklyn bridge, the construction of which devolved upon them after the death of their father in July, 1869.

The directors of the Greenfield Tap & Die Corporation, Greenfield, Mass., on June 9, voted to purchase the entire capital stock of the Greenfield Machine Company, Greenfield, manufacturers of cylindrical and universal grinders, and the Morgan Grinder Company, Worcester, manufacturers of internal grinders. This combination, together with the machines now produced by the Greenfield Tap & Die Corporation, will constitute the machine division of the Greenfield Tap & Die Corporation. The operation and organization of both plants will remain the same for the present, although eventually the Worcester plant will be moved to Greenfield.

Henry T. Gerdes, mechanical engineer and manufacturer, of New York, has been elected president of the Hauck Manufacturing Company, Brooklyn, N. Y., maker of oil burners, oil forges, oil burning appliances, etc. The other officers of the company are: M. C. Hauck, first vice-president; A. B. Hauck, sec-

ond vice-president; H. H. Kress, third vice-president; A. H. Stein, treasurer, and J. Lutz, secretary. Mr. Gerdes, who succeeds the late Arthur E. Hauck as president, is a graduate of Stevens Institute of Technology. He was for many years manager of the Treadwell Engineering Company, Easton, Pa., and has a practical knowledge of the manufacture of oil burning torches and appliances.

William Jordan Caton, secretary of the Burden Iron Company, Railroad and Steamship Division, and assistant to the president of the Sanitation & Supply Company, New York, died on June 17, in the Harbor Hospital, Bath Beach, Brooklyn, N. Y., at the age of 66. He began railway work in the auditor's department of the Boston & Albany at Springfield, Mass., and subsequently served in the passenger department of the same road. He was later purchasing agent of the Pittsburgh & Lake Erie. He served for about nine years as New York representative of Brown & Co., Inc., Pittsburgh, Pa., until July, 1920, when he left the service of that company to go to the Burden Iron Company, Railroad and Steamship Division.

Charles Hosmer Morse, chairman of the board of directors of Fairbanks, Morse & Co., Chicago, died on May 5, at his home in Winter Park, Fla. He was born in St. Johnsbury, Vt., on September 23, 1833, and received his education at St. Johnsbury Academy. Mr. Morse began his business career in 1850, as a clerk in the office of E. & T. Fairbanks & Co., scale manufacturers. In 1862, he became a member of the firm of Fairbanks, Greenleaf & Co., Chicago, successors to E. & T. Fairbanks & Co., and on January 1, 1872, when the firm of Fairbanks, Morse & Co. was established, he became president of that company. He retired as president on May 19, 1915, to become chairman of the board of directors of the same company, at which time he was succeeded as president by his son, C. H. Morse, Jr.

The Manufacturers Exhibition Company, Inc., has established a permanent world market for machinery in the building occupying the block on Sixth avenue, Eighteenth street and Nineteenth street, New York City. The company's plans are broad in scope, including American and international promotion of the sale of all American manufactured mechanical products. There are exhibits of machinery of all kinds and many of the exhibitors have their own representatives in the market, but those who have no one present are represented by trained technicians who will conduct the buyers through the exhibits, explaining all points desired. L. R. Duffield, who was general manager of the Philadelphia Bourse for over ten years and recently general manager of the International Exposition of Industries, is president and general manager of the Manufacturers Exhibition Company, Inc.

George Jesse Foran, for many years manager of the condenser department of the Worthington Pump & Machinery Corporation, New York, died on May 12, at his home in New York City. He was born on January 22, 1862, in Boston, Mass., and graduated from the Massachusetts Institute of Technology in May, 1883, in the department of mechanical engineering, with the degree of bachelor of science. The following September he entered the employ of the Deane Steam Pump Company, Holyoke, Mass., and shortly afterwards was transferred to the Boston office of that company. In November, 1886, he went with the George F. Blake Manufacturing Company as a salesman, and later served also as consulting engineer to the president and treasurer of the Blake company. From 1890 to 1897 he was office manager of the new Blake works at East Cambridge, Mass., also head of the estimating and cost department, later returning to the engineering sales department. The above companies were consolidated with others in 1901 to form the International Steam Pump Company, and Mr. Foran then went to New York, as manager and chief engineer of the condenser department of Henry R. Worthington and the associated companies of the International Steam Pump Company. He continued in that position with the Worthington Pump & Machinery Corporation which succeeded the International Steam Pump Company. Mr. Foran was active in the design of high vacuum apparatus during the entire development of that class of machinery and was at the head of the department at the time of his death. During the war, Mr. Foran served upon the committee for condensing apparatus of the United States shipping board and war industries board and as chairman of the American Engineering Service of the Engineering Council, which dealt with all questions of personnel between the various departments of the United States Government and the four national engineering societies.

TRADE PUBLICATIONS

OXY-ACETYLENE APPARATUS.—A brief outline of gas welding and cutting, together with descriptions and illustrations of acetylene generators, welding and cutting torches, pressure regulators, portable outfits and welding supplies are given in a circular of 16 pages recently issued by the Davis-Bournonville Company, Jersey City, N. J.

VISCOSIMETER CONVERSION CHARTS.—The May 1921 issue of Lubrication, published by the Texas Company, contains a chart for converting viscosimeter readings from one standard to another. By means of the diagram, the time or degrees can be read directly for the Saybolt, Engler, Redwood Admiralty, Saybolt Furol, or Barbey instruments.

WELDING AND CUTTING APPARATUS.—"Alternarc" is the title of a 52-page booklet issued by the Electric Arch Cutting & Welding Company, Newark, N. J. The book opens with a description of this company's standard welding machine and takes up in subsequent chapters welding in the shipbuilding field, steel mills, foundries, machine shops, etc. It also briefly explains the operation of the welding transformer and the advantages of the alternating current arc. Illustrations of welding repair jobs are included.

ELECTRIC HOISTS.—A 12-page booklet has been issued recently by the Electric Hoist Manufacturers' Association, New York, and contains a somewhat lengthy list of successful applications of electric hoists in various industries. No attempt is made to discuss the details of hoist construction or to explain the method and convenience of operation, but numerous illustrations and references are given to show the labor saving effected by electric hoists in conjunction with monorail hoists, gantry and gib cranes.

RAILROAD EQUIPMENT.—An attractive booklet of 36 pages, Catalogue 145, has been issued by the Whiting Foundry Equipment Company, Harvey, Ill., in an effort to place before railroad men the advantages and labor-saving features of various Whiting railroad specialties, including locomotive hoists, coach hoists, cranes, transfer tables, turntable tractors, etc. The booklet also contains a general description and photographs of the company's products, together with numerous illustrations of the apparatus in actual operation. Two typical shop layouts are included.

ARMCO IRON.—"Armco in Picture and Fact" is the title of a well-arranged treatise issued by the American Rolling Mill Company, Middletown, Ohio. After a brief historical sketch of Armco iron, each step in its manufacture from the mining of the ore to the turning out of the finished material, is taken up in an interesting and comprehensive manner. The chemical purity, rust-resistance, welding properties and electrical conductivity of the iron are explained and many other features concerning Armco products. Reference, computing and export tables, and other useful data complete the book.

WATER SOFTENERS.—The Graver Corporation, East Chicago, Ind,. has issued two bulletins describing the company's large continuous water softener (type K) and the small continuous water softener (type KM). Each bulletin opens with a short discussion of water softening and the choice of suitable apparatus. This is followed by descriptions of the operation of the plants which are described in detail and illustrated in numerous photographs. Drawings are shown of typical foundations and upper and lower housings and charts are given to illustrate the loss of water storage space by converting existing storage tanks into water softeners.

OIL DRIVEN AIR COMPRESSORS.—The oil engine driven air compressors manufactured by the Chicago Pneumatic Tool Company, New York, are described and illustrated in bulletin 607, recently issued. The booklet opens with a short general description of the machine and the type of fuel required. This is followed by a condensed illustrated description of the important details of construction. One of the interesting features of the bulletin is a comparison of the cost of operating an oil engine compressor unit and the comparative cost of operating an equivalent sized steam driven compressor. The concluding pages are devoted to illustrations of the various types of machines with tables of sizes, weights, etc.